AD-A156 281 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS WEARE RESERVOIR DAM (..(U) CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV AUG 78 1/1

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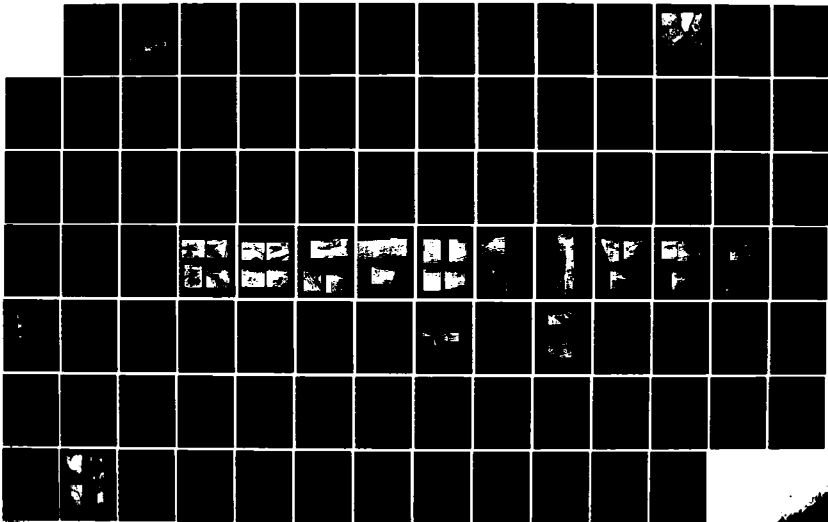

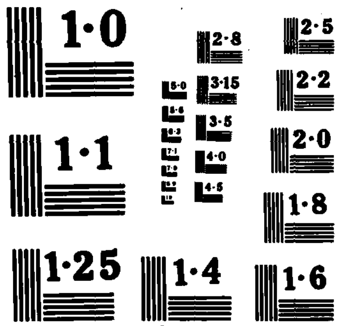
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MERRIMACK RIVER BASIN

WEARE, NEW HAMPSHIRE

WEARE RESERVOIR DAM
NH 00114

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

AUGUST 1978

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NH 00114	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Weare Reservoir Dam NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS		5. TYPE OF REPORT & PERIOD COVERED INSPECTION REPORT
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS DEPT. OF THE ARMY, CORPS OF ENGINEERS NEW ENGLAND DIVISION, NEDED 424 TRAPELO ROAD, WALTHAM, MA. 02254		12. REPORT DATE August 1978
		13. NUMBER OF PAGES 86
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVAL FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,

Merrimack River Basin
Weare New Hampshire
Piscataquog River

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The dam is an on-stream concrete gravity dam. It is 340 ft. long and 34 ft. high. The dam is assessed to be in fair condition. It is recommended that the State carry out ists planned renovation program, with a few additions, within the next couple of years.

DISCLAIMER NOTICE

WEARE RESERVOIR DAM

NH 00114

MERRIMACK RIVER BASIN
WEARE, NEW HAMPSHIRE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam Weare Reservoir Dam

State Located New Hampshire

County Located Hillsborough

City or Town Weare

Stream Piscataquog River

Date of Inspection June 22, 1978

Brief Assessment

Weare Reservoir Dam is an on-stream concrete gravity dam with a long concrete spillway and earth abutments, located at the north end of Weare Reservoir on the Piscataquog River in Weare, New Hampshire. Overall length is 340 feet and height is 34 feet. The original dam was built in 1913 and was reconstructed after being washed out in a 1938 flood. It is operated for recreation and conservation by the State of New Hampshire. The dam is in the significant hazard classification.

Overall condition of Weare Reservoir Dam is assessed to be fair. However, it is recognized that the State has an extensive renovation program planned for the near future, which if successfully carried through will result in the upgrading of the assessment.

A test flood equal to one-half the probable maximum flood would overtop the dam by about 1.5 feet. Spillway capacity is about 71% of the test flood. Overtopping potential is considered moderate.

It is recommended that the State carry out its planned renovation program, with a few additions, within two years.

WHITMAN & HOWARD, INC.

THE STATE OF NEW HAMPSHIRE
TSUNG-TING CHIANG
No. 3049
REGISTERED
PROFESSIONAL ENGINEER

T. T. Chiang

T. T. Chiang, Ph.D., P.E.

THE STATE OF NEW HAMPSHIRE
JOHN L. SCOTT
No. 3834
REGISTERED
PROFESSIONAL ENGINEER

John L. Scott

John L. Scott, P.E.

This Phase I Inspection Report on Weare Reservoir Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

CHARLES G. TIERSCH, Chairman
Chief, Foundation and Materials Branch
Engineering Division

FRED J. RAVENS, Jr., Member
Chief, Design Branch
Engineering Division

SAUL COOPER, Member
Chief, Water Control Branch
Engineering Division

APPROVAL RECOMMENDED

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fraction thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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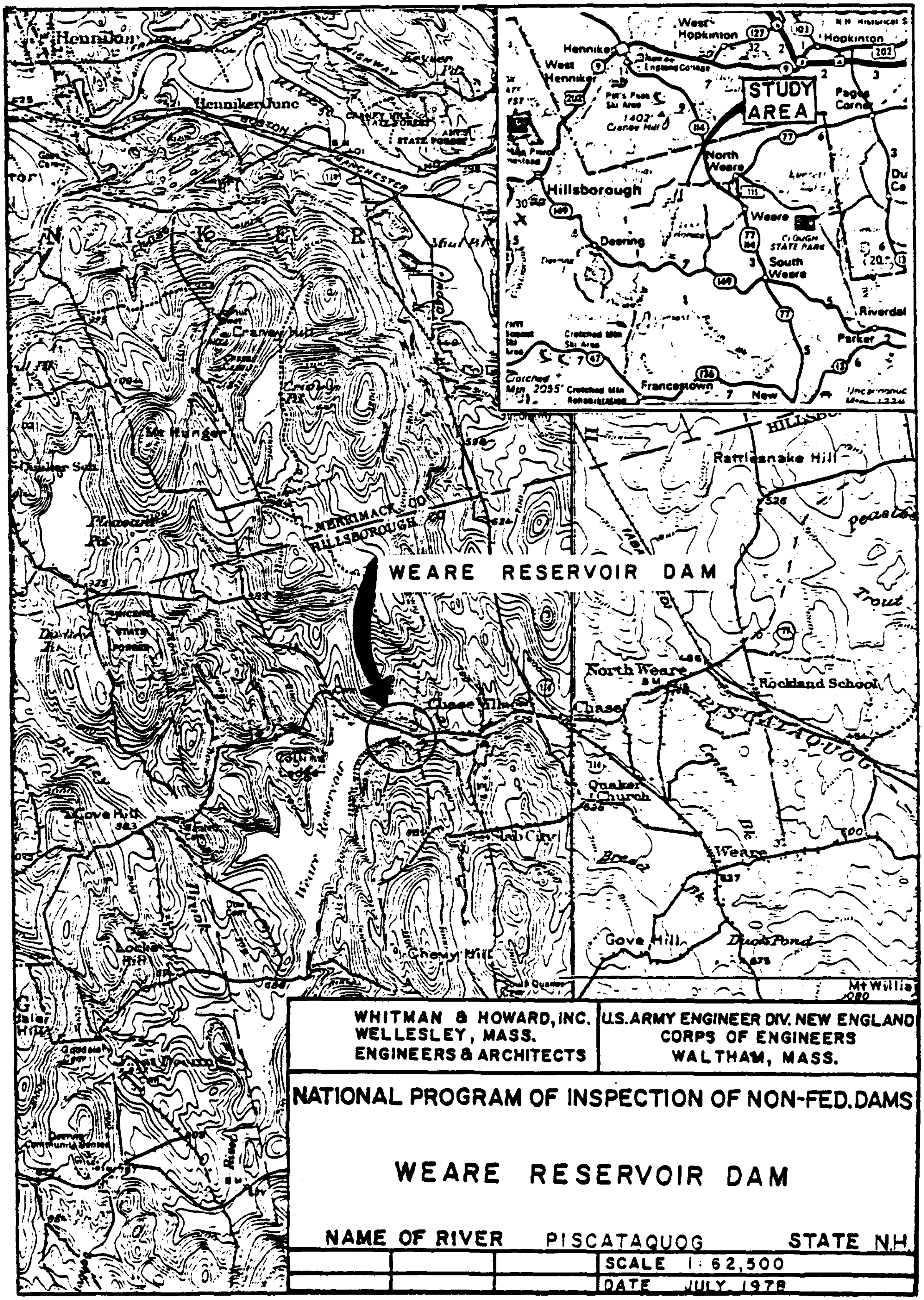
WEARE RESERVOIR DAM

Weare, N.H.

Approx. Scale 1" = 280'


STUDY AREA
WEARE RESERVOIR DAM
Henniker
West Hopkinton
Hopkinton
West Henniker
North Weare
Hillsborough
Deering
Weare
South Weare
Francestown
Riverdale
Parker
Craney Hill
Mt Hunger
Rattlesnake Hill
North Weare
Rockland School
Quaker Church
Gove Hill
Duck Pond
Chase Village
MERRIMACK CO
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U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS
WEARE RESERVOIR DAM
NAME OF RIVER PISCATAQUOG STATE N.H.
SCALE 1:62,500
DATE JULY 1978

PHASE I INSPECTION REPORT

WEARE RESERVOIR DAM

NH 00114

SECTION 1

PROJECT INFORMATION

1.1 General

a. Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Whitman & Howard, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed was issued to Whitman & Howard, Inc. under a letter of May 1, 1978 from Ralph T. Garver, Colonel, Corps of Engineers. Contract No. DACW33-78-C-0313 has been assigned by the Corps of Engineers for this work.

b. Purpose

(1) Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

(2) Encourage and assist the States to initiate quickly effective dam safety programs for non-Federal dams.

(3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location

Weare Reservoir Dam is located on the Piscataquog River at the northern end of Weare Reservoir (also called Lake Horace) in the Town of Weare, New Hampshire. It appears on the U.S.G.S. Quadrangle "Hillsboro, New Hampshire".

b. Description of Dam and Appurtenances

Weare Reservoir Dam is an on-stream concrete gravity dam with a long ogee spillway. The north (left) abutment joins with an earth embankment extending a short distance to a steep hillside. The south end of the dam has a stoplog spillway with crest lowered 2', adjacent to a very short embankment anchored on ledge. Overall dam length is 340 feet and the maximum height from the top of embankment to the low point in the channel is 34 feet.

A 36" low-level discharge pipe is situated in the north abutment and is controlled from a gate house atop the dam. Flow is regulated through this pipe and through the stoplog spillway.

The south end of the dam and central portion are anchored on ledge, but the ledge apparently drops off toward the north end. Construction plans show the north abutment anchored on ledge at its southern end and founded in earth the rest of the way with an impervious soil cutoff. The embankment has an impervious soil core, is riprapped on the upstream face, and has a rock fill toe drain.

Weare Reservoir is totally artificial, there being no natural lake before the dam was constructed.

c. Size Classification

The dam height and impoundment volume of Weare Reservoir places the project at the low end of the "Intermediate" size classification.

d. Hazard Classification

A small community, known as Chase Village, lies downstream, plus a few secondary road bridges. The original dam washed out in a 1938 flood. The records of the flood, which seem fairly thorough, make no mention of deaths caused or large property damage. The Piscataquog River flows into the Everett flood control reservoir downstream. All this leads to the conclusion that the hazard classification of the Weare Reservoir Dam should be "significant" (middle category between low and high).

e. Ownership

The original owner of the dam was the Town of Weare, from 1913-1939. Since then, the dam has been owned by the State of New Hampshire, and administered through the New Hampshire Water Resources Board.

f. Operator

New Hampshire Water Resources Board
37 Pleasant Street
Concord, New Hampshire 03301
603-271-3406

g. Purpose of Dam

The Town of Weare, in cooperation with a power company, built the dam to encourage growth of manufacturing as a town improvement. After the State takeover in 1939, the dam has been operated for recreational purposes.

h. Design and Construction History

The dam was originally built in 1913 by the Town of Weare, through an organization known as the Weare Improvement and Reservoir Association, with some support from the Manchester Traction Light and Power Company. This original dam had an 83 foot long spillway and five feet of freeboard.

In the September, 1938 flood, the rorth abutment failed about 45 minutes after being overtopped, and completely washed away.

Apparently not having the finances to rebuild, the Association turned over rights to the dam to the State of New Hampshire, which agreed to rebuild the dam and operate it for recreation and conservation.

The dam was extensively redesigned. The spillway was doubled in length and the embankments raised two feet. The north embankment was rebuilt in a much more substantial fashion. The improvements served to triple the flow carrying capacity.

The dam has received frequent repairs since then. At the time of this report, the Water Resources Board has a detailed and extensive restoration planned for 1979-1980.

i. Normal Operating Procedures

The operating procedure is a typical recreation cycle. The water level is lowered in the fall about 10 feet below the spillway crest and the stoplogs removed. Spring runoff fills the pond and after the peak of runoff, the flashboards are erected and the water level kept as constant as possible during the summer recreation months.

1.3 Pertinent Data

a. Drainage Area

Total drainage are is 29.04 square miles, of which 4.48 square miles are controlled at Deering Reservoir. The terrain of the watershed is quite rugged, and hydraulically classified as mountainous - rolling.

b. Discharge at Damsite

(1) Maximum known flood - September, 1938; peak flow unknown-dam failed shortly after being overtopped from surge caused by failure of upstream dam. Peak flow probably about 4000 cfs.

(2) Spillway capacity at maximum pond elev. - 12,100 cfs (assumes stoplogs at spillway crest elev.)

(3) Discharge conduit capacity at maximum pond elev. - 260 cfs

(4) Total of spillway capacity plus conduit capacity - 12,360 cfs

c. Elevation (ft. about MSL)

(1) Top Dam - 662.3

(2) Maximum pool-design surcharge - 660 (top dam minus wave ht.)

(3) Full flood control pool - N/A

(4) Recreation pool - top of flashboards - 657.3

(5) Spillway crest - 655.3

(6) Upstream portal invert diversion tunnel - 630

(7) Streambed at centerline of dam - 628

(8) Maximum tailwater - Unknown. Discharges directly to steep natural channel.

d. Reservoir

(1) Length of maximum pool - Approx. 17,800

(2) Length of recreation pool - 14,600 ft.

(3) Length of flood control pool - N/A

e. Storage (acre-feet)

(1) Recreation pool - 6,300

(2) Flood control pool - N/A

(3) Design surcharge - 7,940

(4) Top of dam - 8,600

f. Reservoir Surface (acres)

(1) Top dam - Est. 360

(2) Maximum pool - Est. 350

(3) Flood-control pool - N/A

(4) Recreation pool - 330

(5) Spillway crest - 326

g. Dam

(1) Type - On-stream concrete gravity dam, earth embankments, on ledge and earth.

(2) Length - 340 ft.

(3) Height - 34 ft.

(4) Top Width - North embankment top width 10 ft.

(5) Side Slopes - North embankment 2.5:1 upstream, 2:1 downstream.

(6) Zoning - North embankment impervious core in center.

(7) Impervious Core - Soil, D_{50} = 0.12 mm

(8) Cutoff - Portion of embankment of ledge has short concrete cutoff.

(9) Grout curtain - N/A

(10) Other - Concrete portion of ledge which slopes down from south to north

h. Diversion and Regulating Tunnel

(1) Type - 36" C.I. pipe

(2) Length - Through north abutment, 16 ft.

(3) Closure - Gate valve. Also sluice gate for gate well and bar rack.

(4) Access - Operated from gate house above

(5) Regulating Facilities - Manual operation

i. Spillway

(1) Type - Concrete ogee

(2) Length of weir - 157.3 ft.; stoplog spillway additional 24 ft.

(3) Crest elevation - 655.3

(4) Gates - Stoplog spillway 24 ft. wide, crest 2' lower than spillway

(5) U/S Channel - Earth fill against heel of dam

(6) D/S Channel - Ledge, heavy boulders, steep

(7) General - Central buttress wall, sharply angled training wall at right end.

j. Regulating Outlets

(1) Invert - Stoplog spillway crest - 653.2

(2) Size - 24' long

(3) Description - Depressed sharp crest weir

(4) Control Mechanism - Stoplogs placed manually from overhead walkway.

SECTION 2 - ENGINEERING DATA

2.1 Design

The original 1913 project consisted of, from south to north: a short embankment on ledge, with a stoplog spillway, an earthen embankment with concrete core wall to the center of the dam, an 83 foot long concrete spillway, and the north earth embankment. Original specifications are available, without plans, however. A five page review by Professor Robert Fletcher, Director of the Thayer School of Engineering at Dartmouth College, is also available. These documents give a good picture of the original design intent.

The original spillway capacity was about 2,400 cfs, or 80 cfs per square mile. Professor Fletcher suggested raising the freeboard by 18 inches to increase capacity, but this was apparently not done.

The 1938 flood washed out the north abutment, and destroyed its corewall.

A nearly complete set of reconstruction plans and specifications is available from the 1939 rebuild, plus a quite thorough design report. The key points of the reconstruction were as follows:

(1) Replacing the washed-out north side with a more substantial embankment, and raising the top 2 feet over the original crest.

(2) The north abutment wall was raised and recapped.

(3) The old spillway was capped, keeping the crest elevation the same.

(4) The corewall of the old central embankment was converted into a spillway section (this is the present south half of the ogee spillway).

(5) The south abutment wall was raised.

(6) The highway on the north side was rebuilt.

(7) Other general refurbishment.

At the time of this Phase 1 report, preliminary plans have been prepared by the Water Resources Board for an extensive renovation planned for 1979-1980.

2.2 Construction

Unfortunately, no construction records or data are available to compliment the design information. One good overview photograph exists of the reconstruction as completed.

2.3 Operation

Level records, gate openings, and stoplog operations are kept by the Water Resources Board. The operation is generally the typical recreation cycle.

2.4 Evaluation

a. Availability

Design - Good to excellent
Construction - Not available

b. Adequacy - Good. If it can be presumed that no major blunders or gross changes occurred during construction, the design plans, coupled with records of an extensive recent inspection by the Water Resources Board and the results of the visual observation form a reasonable basis for conclusions.

c. Validity - Good. Records match well with existing condition, as far as can be observed.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

a. General

The results of the visual observation, combined with the records of the December, 1977 inspection by the Water Resources Board - performed with the reservoir substantially drained - form an unusually thorough record of the dam's existing condition.

The remainder of this section deals with the inspection performed as part of this report.

b. Dam

(1) North embankment - the crest of the embankment is unpaved and appears to be used as a vehicle parking area. The upstream slope is covered with riprap. A minor amount of brush and small shrubs were growing through the riprap. A significant amount of erosion has taken place on the upstream face adjacent to the north concrete abutment. The downstream slope is covered with grass, and evidence of minor brush clearing was in existance. The rock toe was observed, and a very minor amount of seepage was noticed.

(2) North abutment - several cracks were observed in the face, probably temperature cracks. The discharge pipe was leaking, flow was about 1-1/4 inches in the 36" pipe.

(3) Spillway - the spillway was difficult to observe because of flow. Erosion looked normal.

(4) Central buttress wall - Spalling moderate.

(5) South training wall - fairly severe weathering plus cracks. Undermined at upstream end.

(6) Stoplog spillway - concrete fair to poor.

(7) South abutment - concrete moderately weathered. Training wall in good condition.

(8) South embankment - in good condition, solidly on ledge.

c. Appurtenant Structures

The gate house appears from the outside to be in fair condition. The metal roof is somewhat crooked. The inspection team did not observe the interior of the gate house or the gate operation.

d. Reservoir Area

There is extensive cottage development, particularly south of the dam.

e. Downstream Channel

The downstream channel of the dam is covered with large boulders and exposed bedrock. Several trees are growing in the channel and trees overhang from the sides. There are several logs lying in the channel.

On the south side of the channel downstream from the stoplog spillway, soil is eroding from a steep slope. Bedrock is exposed several feet above the channel bottom and the soil above the bedrock is actively eroding. Trees at the top of the slope are leaning over the channel, and a cabin is situated a short distance from the top of the slope and could be endangered by continued erosion.

3.2 Evaluation

Based on the visual examination, the north embankment of the dam is in good condition. Erosion of the upstream slope adjacent to the abutment should be repaired. A grass cover should be established on the crest and trespassing should be controlled. The minor seepage at the toe should be monitored. The erosion in the bank downstream from the stoplog spillway must be arrested to prevent eventual damage to the private cottage.

Several areas of the concrete surface are in poor condition, mostly spalling, weathering and temperature cracks. Nothing in the concrete condition indicates gross instabilities. It is known that the Water Resources Board is well aware of these conditions and is making plans for their correction.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

The operating procedures follow a typical recreation cycle. See 1.2 i.

4.2 Maintenance of Dam

The dam has received conscientious and knowledgeable maintenance. Present deficiencies have been closely monitored and plans are being prepared for their correction.

4.3 Maintenance of Operating Facilities

Records claim the gate to the 36" discharge pipe is in good operating condition, though this was not observed by the inspection team.

4.4 Description of Any Warning System in Effect

Although the dam is not observed continually, the Water Resources Board has the expertise to foresee common dangers and provide knowledgeable warning.

4.5 Evaluation

Operational procedures seem adequate.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design Data

The original 1913 dam was designed for only about 80 cfs/square mile. The spillway redesign in 1939 was governed more by practical considerations (a convenient method of enlarging the spillway by converting the central embankment to a spillway presented itself) than by any particular discharge criteria. The improvements more than tripled flow capacity.

b. Experience Data

The 1938 flood caused failure of the dam shortly after the old north embankment was overtopped. Peak flow is unknown, since the failure most probably occurred shortly after a surge caused by an upstream dam failure. 4000 cfs seems like a reasonable estimate. The present dam could pass this flow without overtopping.

c. Visual Observations

From historical photographs and the visual inspection, it appears that this reservoir is plagued more than most by debris, particularly logs. Continual clearing of the crest and downstream channel of debris is necessary to preserve the full capacity of the spillway.

d. Overtopping Potential

Reference is made to Appendix D for the hydrologic computations performed as a part of this report.

The probable maximum flood (PMF) is computed to be about 42,000 cubic feet per second (cfs) inflow into the reservoir. The PMF is defined as the largest flood that can reasonably be expected to occur on a given stream at a selected point, or the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

For dams in the intermediate size classification and significant hazard classification, the "test flood" is generally chosen between one-half of the PMF and the full PMF. The test flood is that flood used to evaluate the hydraulic adequacy of a project. The test flood for Weare Reservoir Dam is chosen as one-half the PMF.

During the test flood peak outflow at the dam would be about 17,300 cfs, the reduction from 21,000 cfs inflow being accounted for by the surcharged storage "cushion" effect of the reservoir. The spillway capacity, including the stoplog spillway and neglecting wave overtopping, is about 12,360 cfs or 71% of the test flood. Overtopping potential is moderate. A flow of 17,300 cfs would overtop the dam by about 1.5 feet, probably sufficient to wash out the north abutment, the most vulnerable part of the dam. If the dam failed, the depth of flow downstream would be in the order of 10 feet. However, due to the steep slope, the velocity of the flood flow would be over 10 ft./sec. Flood flow with high velocity generally causes high damage.

Since this reservoir is only used for recreation, it is suggested that the reservoir be emptied during the winter season and filled back slowly during early spring. This would reduce the chance of the Spring flood which is usually a combination of storm rainfall and snowmelt.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

No evidence was found of gross structural instability. There is, however, evidence of problems which could become serious if allowed to progress.

Soil erosion is occurring on the upstream face of the north abutment and also along the south downstream bank, caused by discharge flow from the stoplog spillway. The latter is progressing towards undermining the foundation of a small private cottage.

Concrete surfaces are spalled and weathered in various places and there are a significant number of concrete cracks, probably temperature cracks.

b. Design and Construction Data

Design data is fairly complete, except for designer's computations, and indicate that the dam design was a professional effort. The 1939 reconstruction made good use of the portions of the structure not harmed in the flood.

Unfortunately, no construction records or data have survived to the present time.

c. Operating Records

Apparently, the pond used to be lowered more in the fall than is done presently. A study of the results of the 1977 Water Resources Board inspection show two areas of ice damage to the upstream face of the spillway. One is around the level apparently used for winter operation, and the other is quite a few feet lower.

d. Post Construction Changes

The stoplog spillway and south abutment was rebuilt in 1954, and the south training wall was also added at that time.

Various other smaller repairs have been made frequently.

d. Seismic Stability

This dam is in Seismic Zone 2 and hence does not have to be evaluated for structural stability according to the OCE Recommended Guidelines.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition

Weare Reservoir Dam is assessed to be in overall fair condition. It is recognized that the Water Resources Board is well aware of the various deficiencies and is planning extensive renovations for the near future. Study of the proposed renovation program indicates that with its successful completion, the dam assessment will be considerably upgraded.

b. Adequacy of Information

Design information is quite good, and an unusually complete analysis is available of the present condition of the dam. However, no construction records exist which would serve to complete the background data. Very little hard information is available regarding soils and geology.

The proposed program of renovations, planned for 1979-1980 by the Water Resources Board includes the following steps:

(1) Refacing the upstream face of the spillway.

(2) Capping and refacing the middle buttress wall.

(3) Refacing the downstream face of the north abutment.

(4) Removing and replacing the pier and training wall on the north side of the stoplog spillway.

(5) Remounting the stoplog spillway catwalk.

(6) Patching the downstream side of the stoplog spillway and refacing the south abutments of the stoplog spillway.

(7) Erecting a new 80 foot long retaining wall on the south downstream bank and placing earth fill to remedy the erosion.

c. Urgency

The recommendations and remedial measures mentioned below should be carried out within one to two years, as planned by the Water Resources Board.

d. Need for Additional Investigation

Based on the visual observation and the study of the 1977 Water Resources Board inspection, no need exists for additional inspections.

7.2 Recommendations

The owner should carry out the proposed restoration plan with the following additions:

(1) Provide erosion protection on the crest of the north embankment (e.g. paving or grass) and take measures to prevent unauthorized vehicle access to the crest.

(2) Repair the soil erosion on the upstream face of the north embankment adjacent to the concrete abutment.

7.3 Remedial Measures

a. Alternatives - N/A

b. Operating and Maintenance Procedures

The owner should monitor the slight seepage at the downstream rock filled toe drain of the north embankment for any changes. The owner should also investigate the apparent leakage of the 36" gate and make repairs as necessary.

WEARE RESERVOIR DAM

APPENDICES

Appendix	Description
A	Visual Inspection Checklist - 7 pp.
B	Engineering Data with Index
C	Inspection Photographs with Index - 8 photos
D	Hydrologic Computation
E	Information as Contained in the National Inventory of Dams

APPENDIX A

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT Weare Reservoir Dam

DATE June 22, 1978

TIME 3:30 PM

WEATHER Clear

W.S. ELEV. 655.4 U.S. ____ DN.S.
(1" over spillway)

PARTY:

1. T. T. Chiang, W&H
2. J. Scott, W&H
3. R. Hirschfeld, GEI
4.
5.
6.
7.
8.
9.
10.

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Soils & Geology	R. Hirschfeld	
2.	Rest	Scott, Chiang, Hirshfeld	
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

PERIODIC INSPECTION CHECK LIST

PROJECT Weare Reservoir Dam DATE 6/22/78

PROJECT FEATURE North embankment NAME R. Hirschfeld

DISCIPLINE ______ NAME ______

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	
Current Pool Elevation	
Maximum Impoundment to Date	
Surface Cracks	None observed
Pavement Condition	Not paved
Movement or Settlement of Crest	None observed
Lateral Movement	None observed
Vertical Alignment	Good
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Some erosion at contact between embankment and concrete section
Indication of Movement of Structural Items on Slopes	None observed
Trespassing on Slopes	None observed
Sloughing or Erosion of Slopes or Abutments	None observed
Rock Slope Protection-Riprap Failures	None observed
Unusual Movement or Cracking at or near Toes	None observed
Unusual Embankment or Downstream Seepage	Minor seepage at downstream toe
Piping or Boils	None observed
Foundation Drainage Features	None observed
Toe Drains	Rock fill toe
Instrumentation System	

PERIODIC INSPECTION CHECK LIST

PROJECT Weare Reservoir Dam DATE 6/22/78

PROJECT FEATURE 36" conduit system NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
OUTLET WORKS-INTAKE CHANNEL AND INTAKE STRUCTURE	
a. Approach Channel	
Slope Conditions	No slopes - left side of approach to intake is vertical cone abutment
Bottom Conditions	Not visible
Rock Slides or Falls	None
Log Boom	Plans show bar rack - could not see
Debris	Lots of debris across spillway and in downstream channel
Condition of Concrete Lining	Unknown
Drains or Weep Holes	None
b. Intake Structure	Brick masonry gate house - exterior in fair condition. Did not see interior.
Condition of Concrete	
Stop Logs and Slots	

PERIODIC INSPECTION CHECK LIST

PROJECT Weare Reservoir Dam DATE 6/22/78

PROJECT FEATURE Outlet of 36" pipe NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
OUTLET WORKS-TRANSITION AND CONDUIT	
General Condition of Concrete	
Rust or Staining on Concrete	None observed
Spalling	None
Erosion or Cavitation	Concrete pad on which 36" pipe discharges has normal erosion
Cracking	None observed
Alignment of Monoliths	1-1/4" flow observed in 36" pipe - probably leakage through gate
Alignment of Joints	
Numbering of Monoliths	

PERIODIC INSPECTION CHECK LIST

PROJECT Weare Reservoir Dam DATE 6/22/78

PROJECT FEATURE Stoplog spillway NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
OUTLET WORKS-OUTLET STRUCTURE AND OUTLET CHANNEL	Stoplog Spillway
General Condition of Concrete	Sill worn
Rust or Staining	None
Spalling	Some - not severe
Erosion or Caviation	Normal
Visible Reinforcing	None
Any Seepage or Efflorescence	None
Condition at Joints	The channels holding the logs are rusted
Drain Holes	Drain holes in south abutment OK
Channel	
Loose Rock or Trees Overhanging Channel	Yes, also trees
Condition of Discharge Channel	Much debris

PERIODIC INSPECTION CHECK LIST

PROJECT Weare Reservoir Dam DATE 6/22/78

PROJECT FEATURE ______ NAME ______

DISCIPLINE ______ NAME ______

AREA EVALUATED	CONDITION
OUTLET WORKS-SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	No approach channel as such - dam is "on-stream"
General Condition	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Approach Channel	
b. Weir and Training Walls	(Note: surface had 1" flow - somewhat difficult to inspect)
General Condition of Concrete	Normal erosion. North abutment some temp. cracks. South training wall poor.
Rust or Staining	None
Spalling	Middle buttress wall spalled on both faces
Any Visible Reinforcing	None
Any Seepage or Efflorescence	None
Drain Holes	
c. Discharge Channel	
General Condition	Large boulders, ledge
Loose Rock Overhanging Channel	Yes
Trees Overhanging Channel	Yes
Floor of Channel	Trees growing in channel
Other Obstructions	Much debris

PERIODIC INSPECTION CHECK LIST

PROJECT Weare Reservoir Dam DATE 6/22/78

PROJECT FEATURE Catwalk for Stoplog Spillway NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
OUTLET WORKS-SERVICE BRIDGE	
a. Super Structure	
Bearings	Both ends of catwalk fixed - has caused bowing & cracking - no room for temp. expansion.
Anchor Bolts	
Bridge Seat	Railings & surface good.
Longitudinal Members	
Under Side of Deck	
Secondary Bracing	
Deck	
Drainage System	
Railings	
Expansion Joints	
Paint	
b. Abutment & Piers	
General Condition of Concrete	North abutment of stoplog spillway weathered & cracked.
Alignment of Abutment	
Approach to Bridge	
Condition of Seat & Backwall	

APPENDIX B

ENGINEERING DATA

Plate-Plan & Section - traced from 1939 reconstruction plans

Inspection report by NH Water Resources Board, 12/14/77, with 10 pages of photos & photo index

Memo about upstream face - 11/21/63

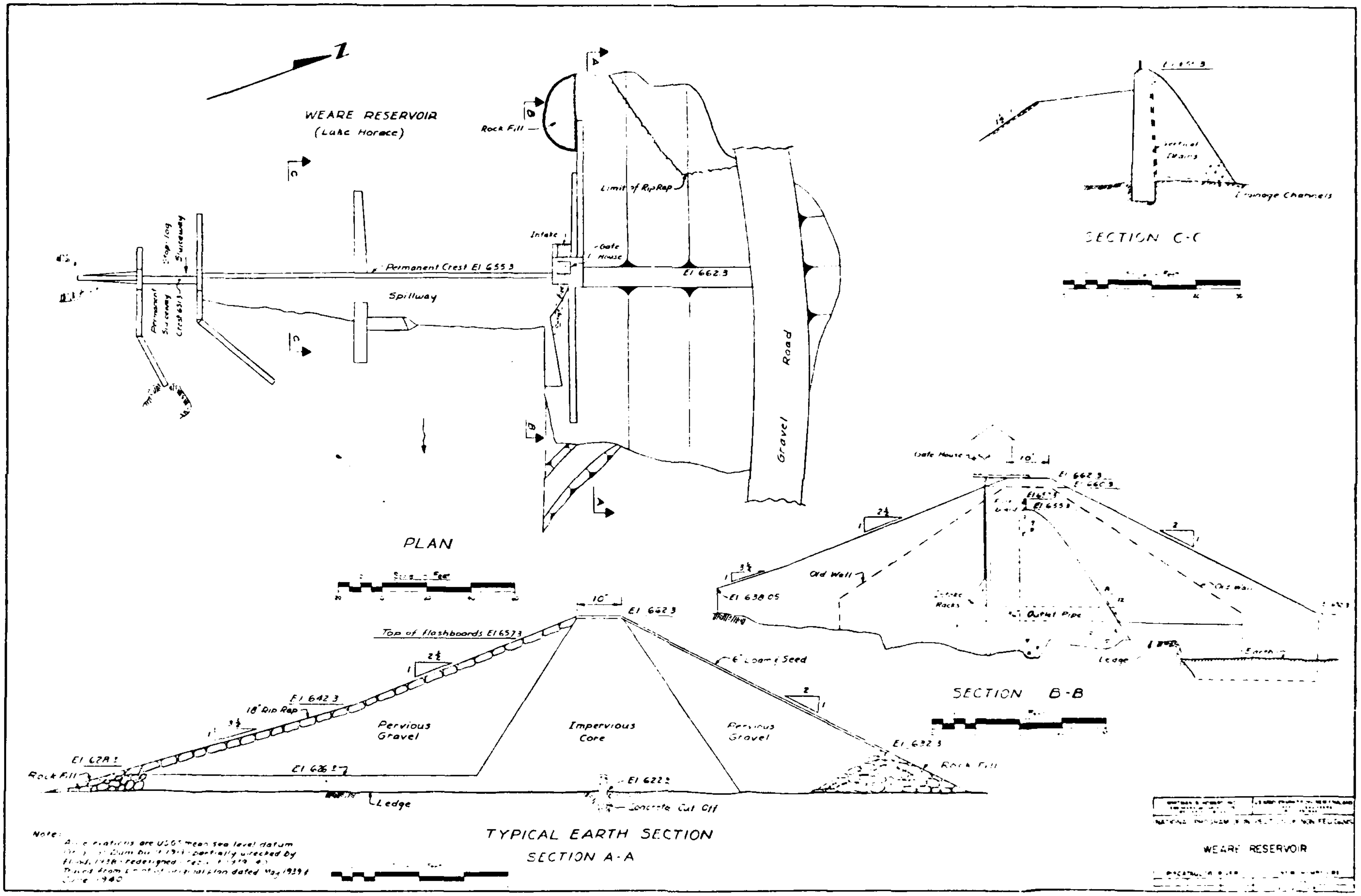
Overview photo of completed reconstruction, May, 1941

"Report on Reconstruction of Dam and Highway at North Weare Reservoir", NH Water Resources Board, March, 1940 - first 7 pages

Mechanical analysis of core material (Appendix of above report)

Original Contract and Specifications, 1/18/13 - 6 pages

Review of original design by Prof. R. Fletches, Thayer School of Engineering - 5 pages with sketch



WEARE RESERVOIR
(Lake Horace)
Rock Fill
Permanent Crest El 655.3
Spillway
Stop-log Sluiceway
Permanent Sluiceway Crest 651.3
Intake
Gate House
El 662.3
Limit of RipRap
Gravel Road
PLAN
SECTION C-C
Drainage Channels
Gate House
10'
El 662.3
Old Wall
El 638.05
Intake Racks
Outlet Pipe
Ledge
SECTION B-B
10'
El 662.3
Top of flashboards El 657.3
18" Rip Rap
El 642.3
Pervious Gravel
Impervious Core
Pervious Gravel
6" Loam & Seed
El 628 ±
El 606 ±
El 622 ±
El 632.3
Rock Fill
Ledge
Concrete Cut Off
TYPICAL EARTH SECTION
SECTION A-A
WEARE RESERVOIR

STATE OF NEW HAMPSHIRE

INTER-DEPARTMENT COMMUNICATION

DATE December 14, 1977

ROM Stephen C. Burritt SCB

AT (OFFICE) Water Resources Board

UBJECT Weare Reservoir - November 1976 inspection

TO File

1. RightEmbankment:

Concrete, about 2' wide at the top with battered sides. Founded on ledge. The concrete is in good shape and this area requires no repairs at this time. See photo #2.

2. Right Abutment & retaining wall

The retaining wall was new with the 1954 Repairs. The drain holes at the base of this appear to be open and working. At this timethere was no water in the. The Abutment concrete is weathered but appears to be structurally sound with no large holes or cracks (see photo #1). The stoplog section is made by bolting a channel to the abutment (photo 3). This was grouted in and this has washed out and been repaired several times, the latest being Spring 1976. This channel should be removed and replaced as it is heavily rusted. The Abutment should be refaced and a new stoplog slot be cast in this new facing.

3. Stoplog Spillway:

This is a concrete spillway founded on ledge. The stantion beams are grouted in the concrete (see photo #5). The concrete is in good shape, but it does show signs of wear. There is one area shown in the photo where the ledge has dislodged itself, this area should be concreted back in.

4. Sluiceway (below stoplog section)

This area is founded on ledge and has sand and gravel on top. This is washing back into the bank and will be threatening the safety of one camp in a few years. A retaining wall should be built in this area. This wall would be about 10' tall and 100 to 135 feet long. Because of the large drop, several energy disapators should be built between the existing wall and the proposed wall.

5. Stoplog Pier:

This pier is in poor shape. There are several cracks and the concrete is weathered badly (see photos 6, 7, 10, 11). This should be chipped down to solid concrete and refaced. It appears that the catwalk has been rigidly fastened to this pier and also at the other end at the abutment the expansion and contraction of the steel beams may have caused part of the cracks in the pier. The catwalk could be lowered about 3 feet to make operation easier and still be above the flow level at a 100 year flood. When the new catwalk is installed it should be anchored only at one end.

6. Retaining wall (below stoplog pier)

This is a concrete wall with no reinforcement. This wall has several cracks where the wall has shifted due to expansion and contraction. This wall should be refaced.

7. Right spillway (South spillway)

This spillway was new in 1938 and the upstream face extends down about 5 to 6 feet below the crest. At the time of construction this face was back-filled with earth. This material has been washed away exposing the bottom of the refacing.

This area should be back filled and riprap placed on top of the fill to reduce the erosion. The concrete in this area is in good shape. There are a few very small areas that are in need of repair. These can be patched with an epoxy type repair.

8. Lt Spillway (North spillway)

This is the original spillway that was refaced on the downstream side and capped when the Rt spillway was built. The downstream face is in good shape except for a few areas that can be patched. The upstream face (see photos 13, 19,20) has been eroded in two areas. One about 6' below the spillway crest and the other about 15' to 18' below the spillway crest. These were caused by ice action. The lower area was present in the late 1930's and due to the operations that were done at that time. This upstream face should be refaced with about 8" to 1' of concrete. This area should go from the crest down about 15' to cover.

9. North Abutment

This abutment is in fairly good shape. There is some concrete erosion in the location of a cold joint but this could be repaired with an epoxy.

10. Gates:

Both gates are in good working order.

11. Earth Embankment:

There are some areas near the North abutment that should be filled and covered with loam and seeded. The downstream slope should be cleared of heavy growth.

HAMPSHIRE
R RESOURCES
BOARD
CO. D, N. H.

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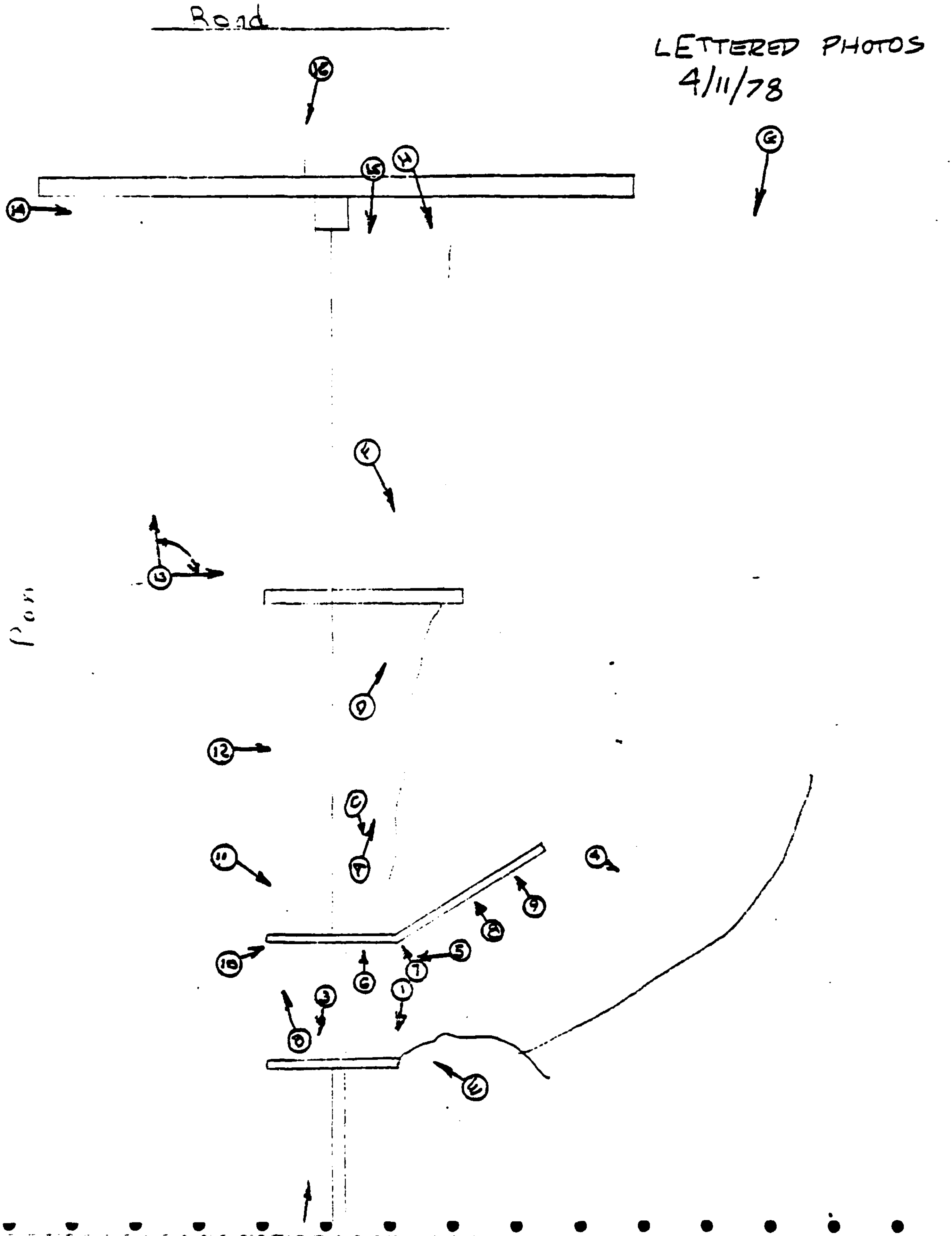

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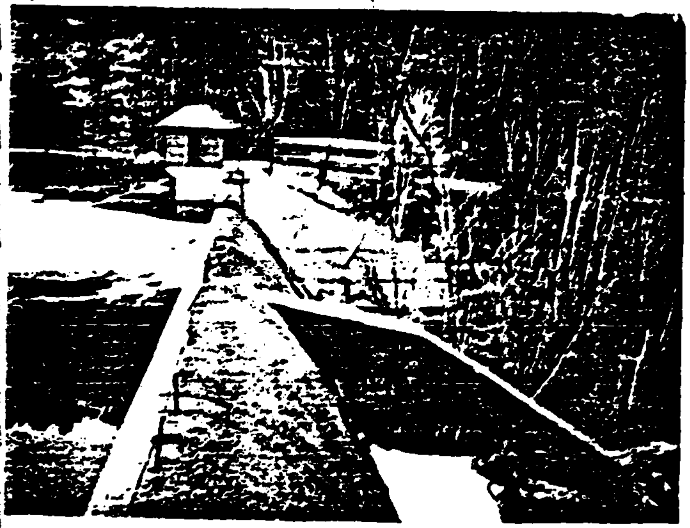
4/11/78

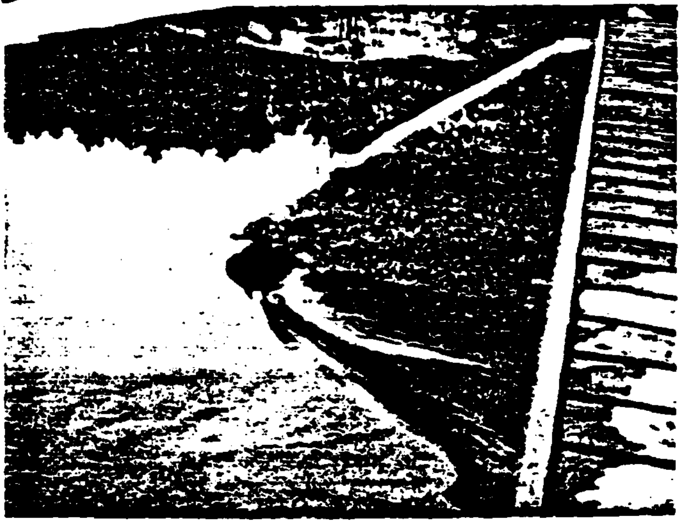
CRACKS

A

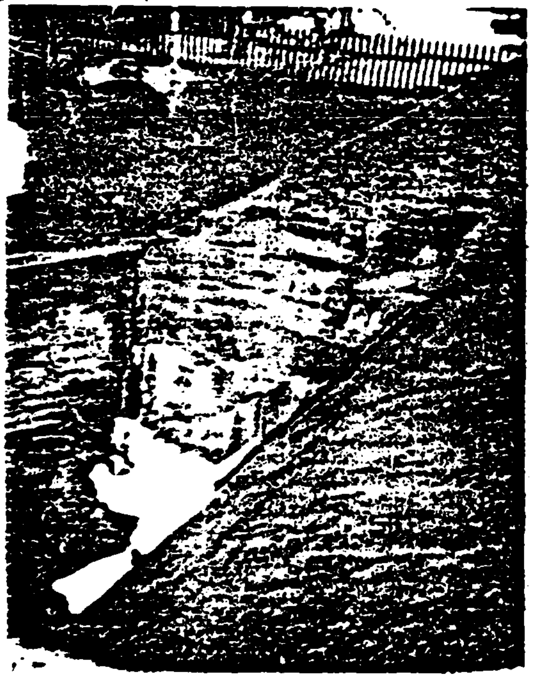


WATER FLOWING UNDER CONCRETE

B



C SPALLING & LEACHING



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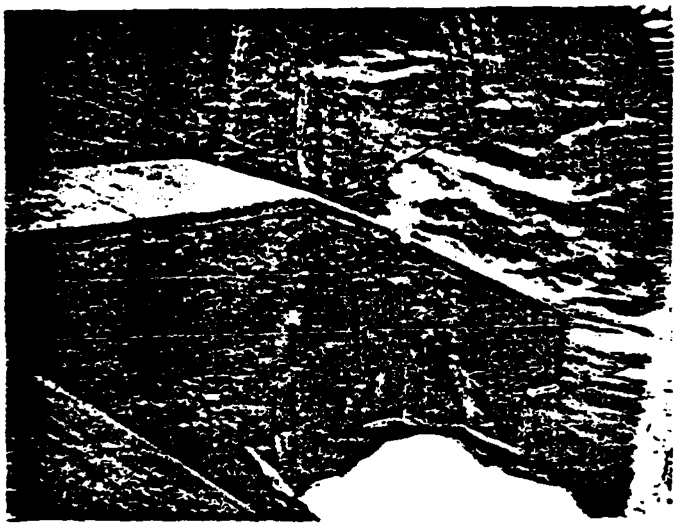

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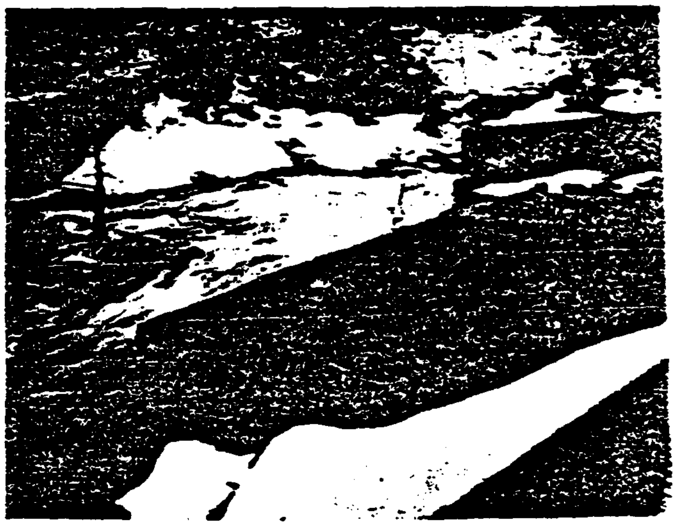

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FORM E2

NEW HAMPSHIRE
WATER RESOURCES
BOARD
CONCORD, N. H.

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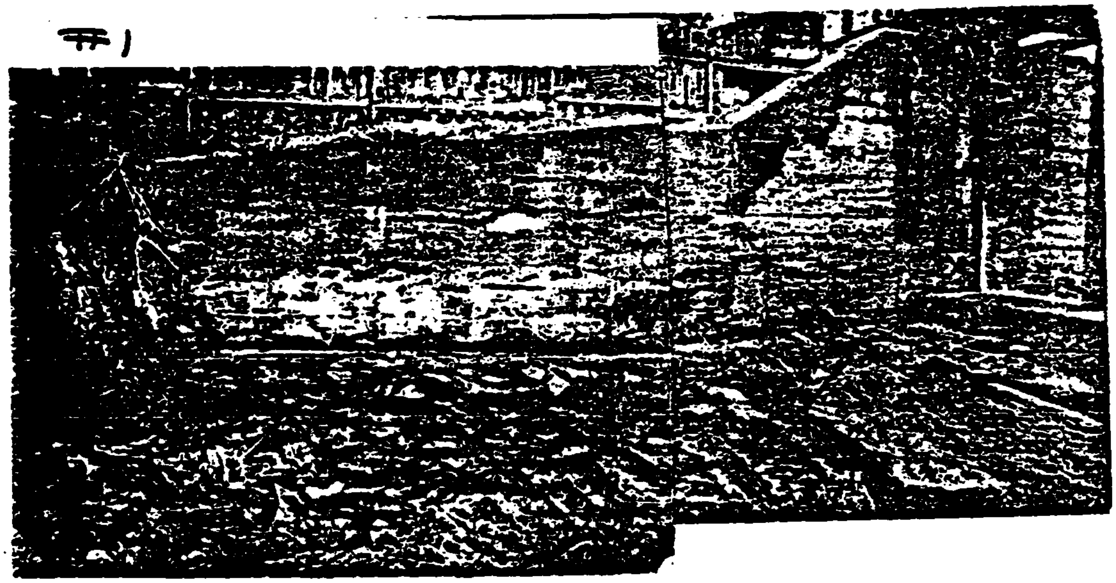
#1



#2

Cold Joint

#3

NEW HAMPSHIRE WATER RESOURCES BOARD CONCORD, N. H.

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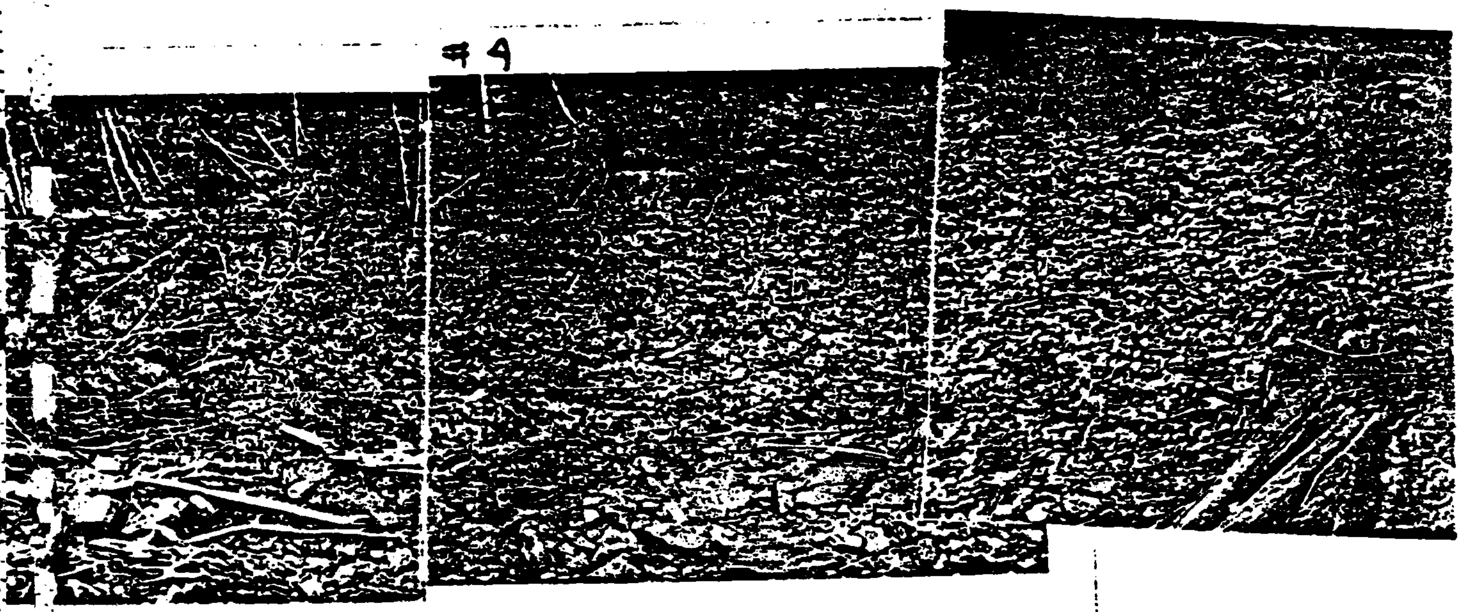

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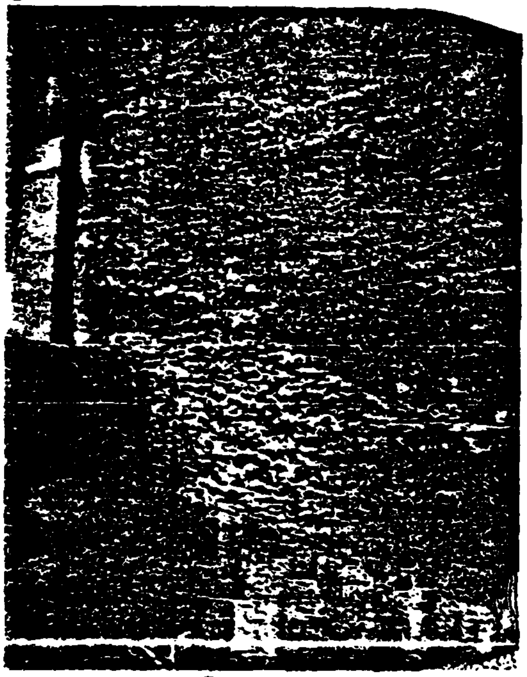

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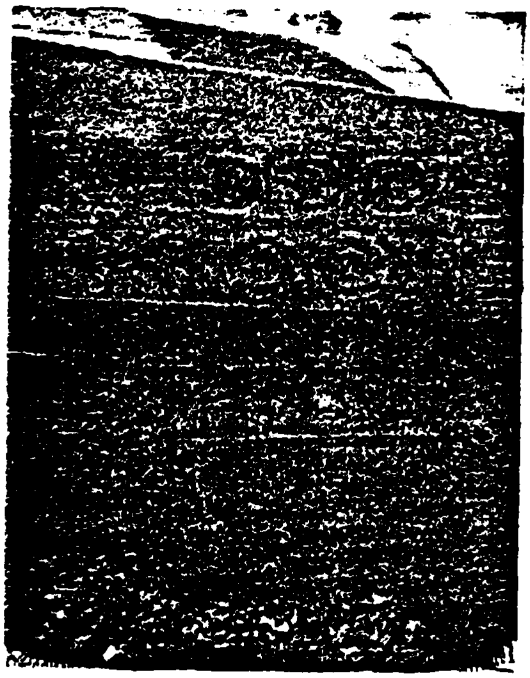

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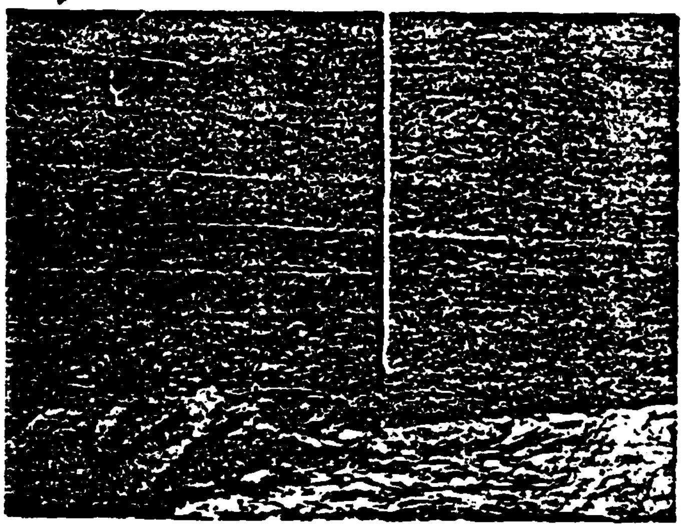

Form 12

NEW HAMPSHIRE WATER RESOURCES BOARD CONCORD, N. H.

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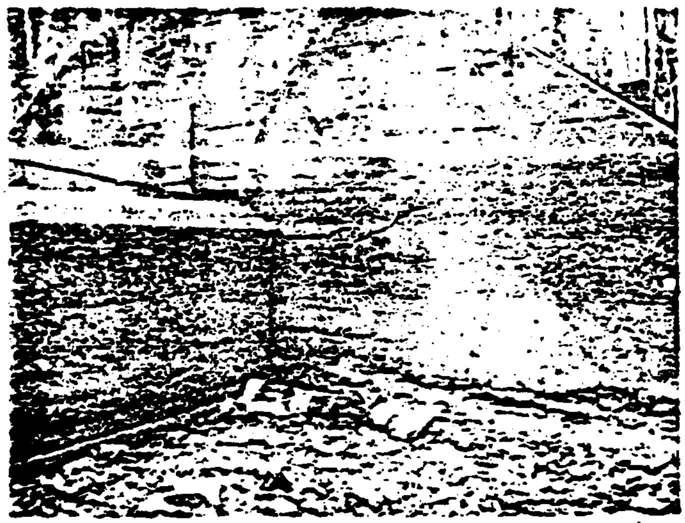

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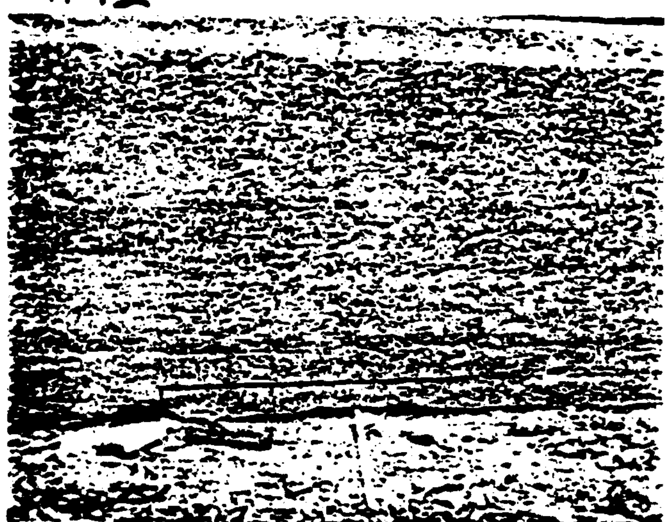

NEW HAMPSHIRE WATER RESOURCES BOARD CONCORD, N. H.

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SUBJECT ____ ACC ____

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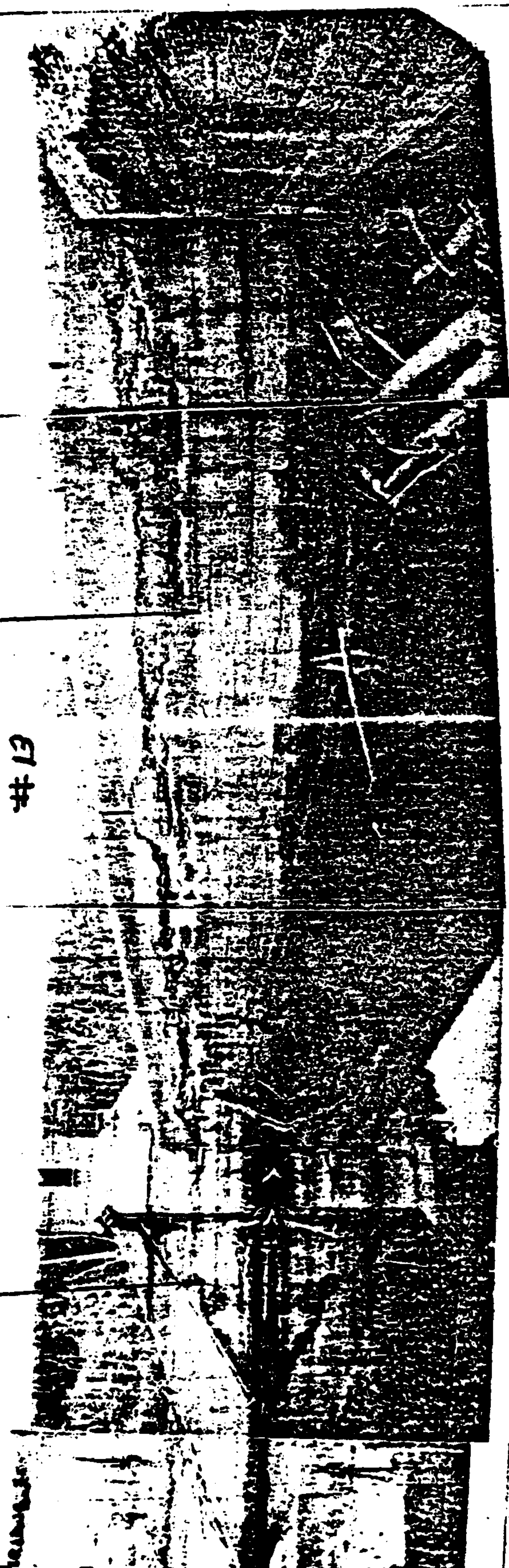
Cold Joint

#13



Cold Joint

FORM 23

NEW HAMPSHIRE WATER RESOURCES BOARD CONCORD, N. H.

PROJECT

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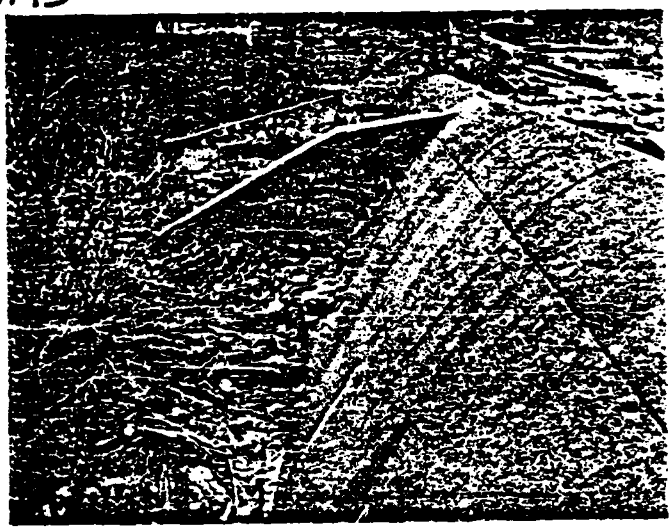
FILE

ACC.

#14

Cold Joint

#15



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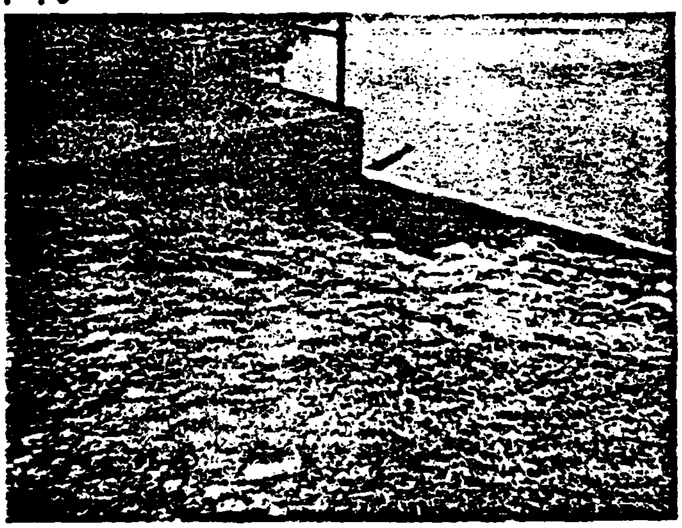

NEW HAMPSHIRE WATER RESOURCES BOARD
CONCORD, N. H.

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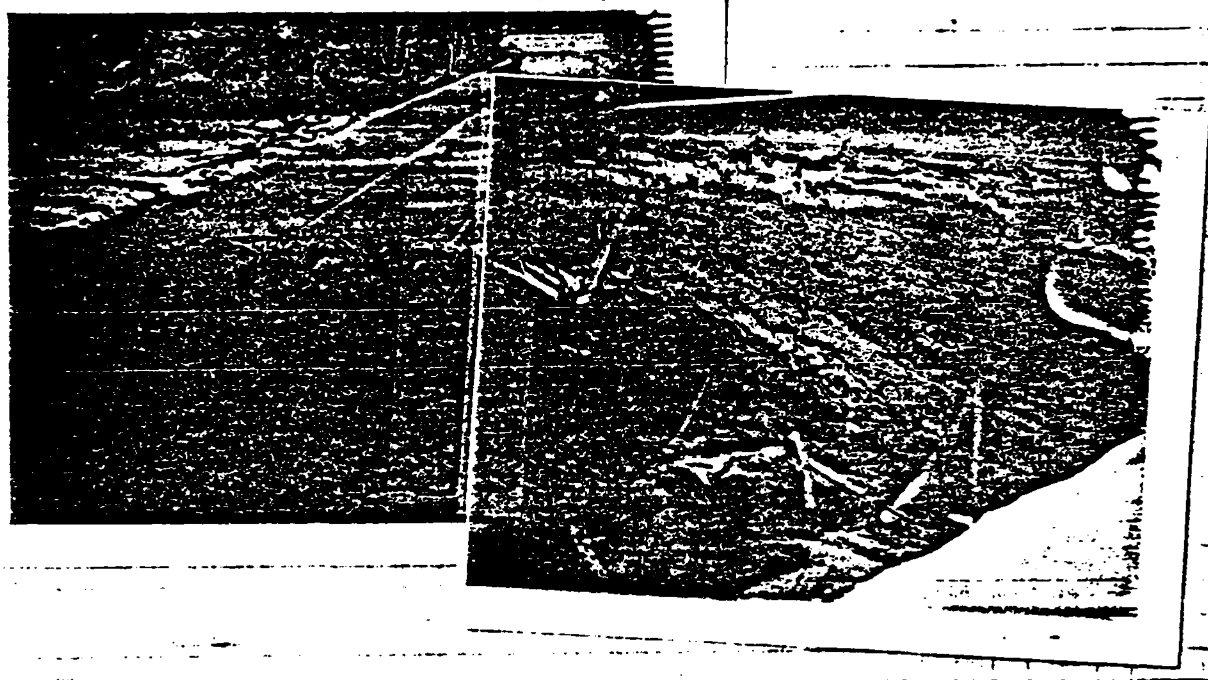

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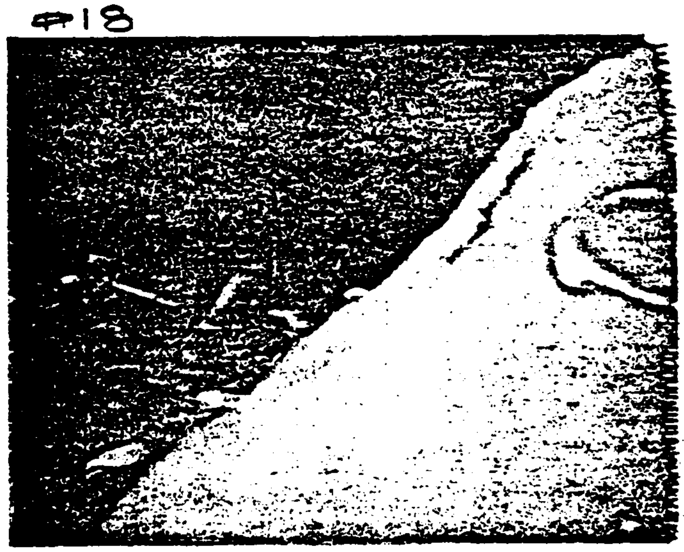

NEW HAMPSHIRE WATER RESOURCES BOARD
CONCORD, N. H.

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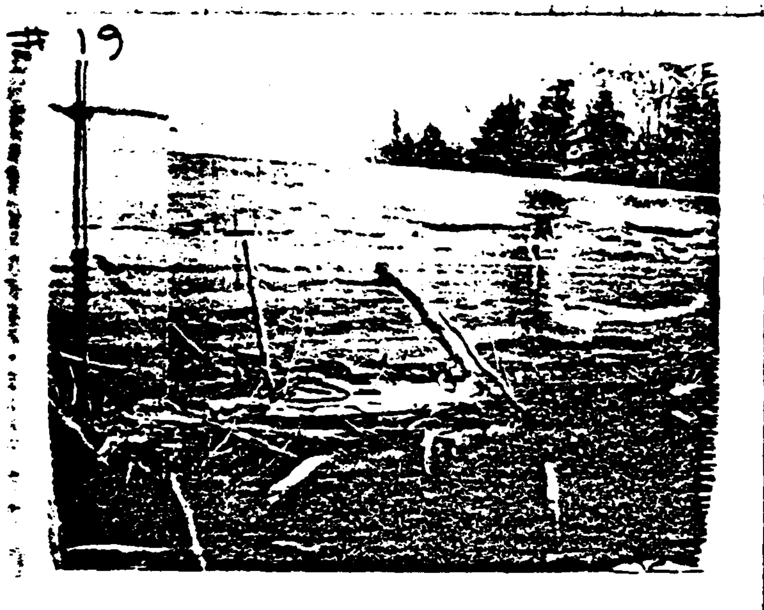

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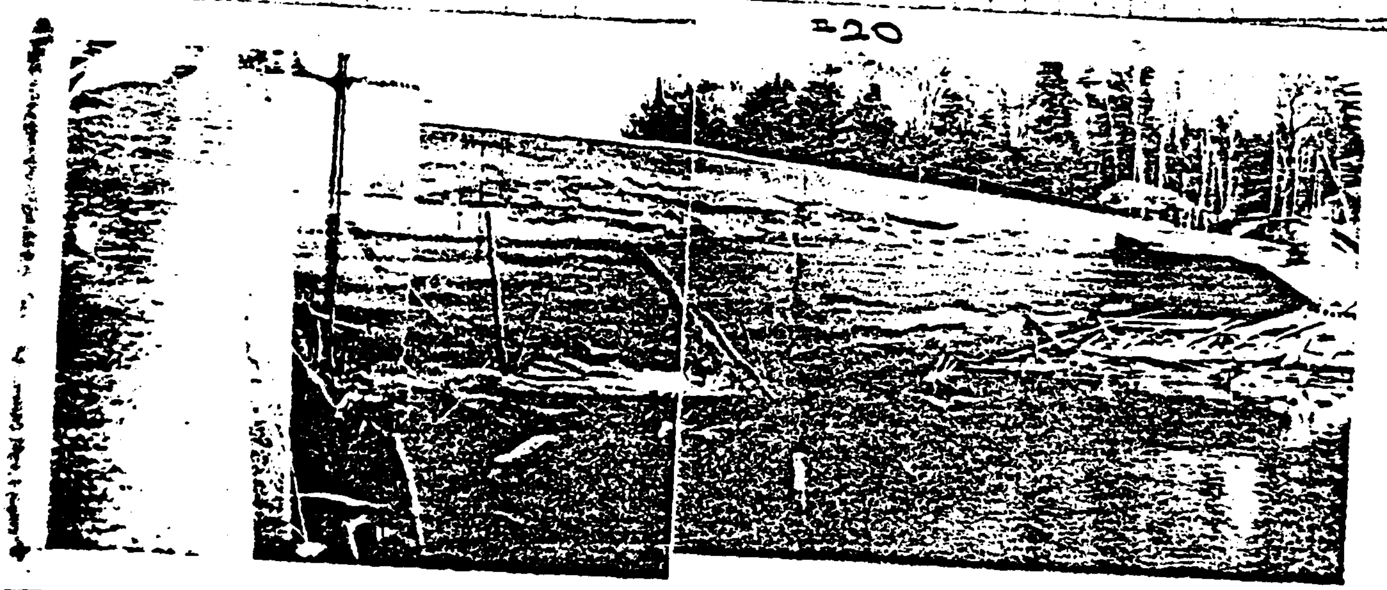


MEMORANDUM

RE: Inspection of Weare Reservoir Dam - November 21, 1963

An inspection was made of the upstream face of Weare Reservoir Dam adjacent to the gate house on November 21, 1963. The area in question had been inspected in 1954 and photographs taken at that time showed scaling concrete about 16 feet below the crest running across this section.

During this inspection, it was noted that this original scaling area had not appeared to change in size or shape near the water surface at 13 feet below the crest. However, at the upper level of the dam 3 - 5' below the crest, the former small scaled areas have increased in size. This condition was probably caused by the action of ice at this level.

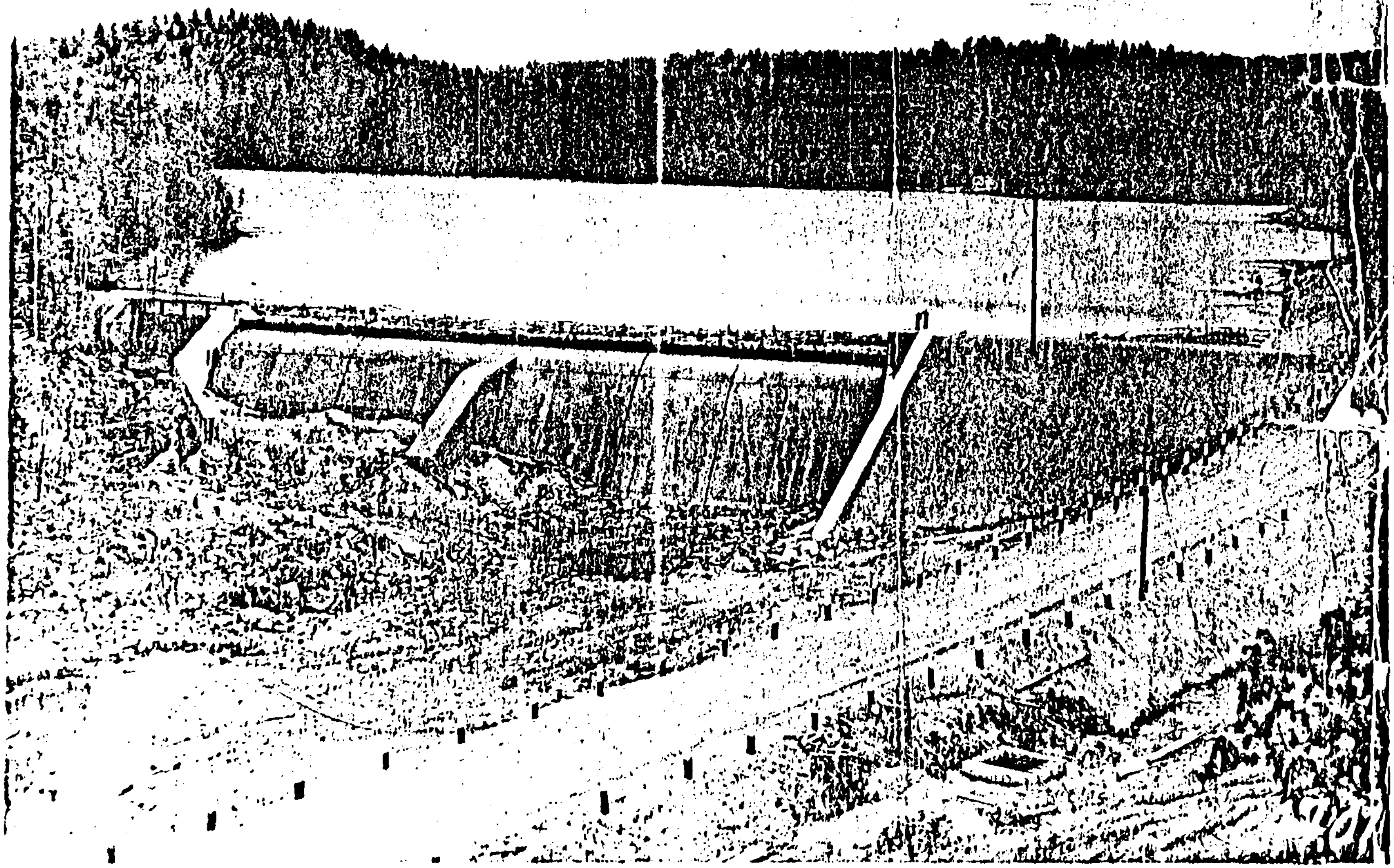
The extent of this scaling does not appear to have changed sufficiently in the past 9 years to warrant repairs.

It is recommended that these areas be checked regularly and if substantial changes are noted, the necessary repairs should be made.

Vernon A. Knowlton

Vernon A. Knowlton
Civil Engineer

PHOTO DATED MAY 1941



NEW HAMPSHIRE WATER RESOURCES BOARD

REPORT ON

RECONSTRUCTION OF DAM AND HIGHWAY

AT

NORTH WEARE RESERVOIR

CONCORD, N. H.
MARCH 1940

INDEX

REPORT ON

RECONSTRUCTION OF WEARE RESERVOIR DAM AND HIGHWAY

AT

NORTH WEARE, NEW HAMPSHIRE

SUMMARY AND CONCLUSIONS

The Weare Reservoir Project consists of rebuilding a dam across the Piscataquog River and an adjacent highway, both washed out during the flood of September 1938. This dam, located in Weare, will form a recreational and flood control reservoir owned and controlled by the State of New Hampshire. Surveys have been made, designs prepared, construction bids received and the following report written. The major facts found are:

1. The reservoir will have a water surface area of 330 acres and a gross capacity of 8,300 acre feet.

2. The reconstruction work will consist of replacing the earth embankment at the north end of the dam with its top raised two feet and with flatter slopes upstream and downstream. The spillway will be lengthened and its discharge capacity increased more than three times.

3. The estimated cost of the project is $33,801.

4. Funds are available to meet the complete cost of the project.

5. The annual cost of the project is estimated at $100.

6. The benefits from the project are mostly the recreational benefits which will result from a lake maintained at a constant elevation during the summer months. The water level in the reservoir will be lowered during the fall and winter to provide capacity for storing flood waters so that flood damage to communities on the river downstream will be reduced. Some power benefits will result to hydroelectric plants on the Piscataquog River when the water is released.

7. The dam and flowage rights are now owned by the Weare Improvement and Reservoir Association. This Company has offered to deed all rights in the project to the State of New Hampshire for one dollar with the only reservation that if the property is sold to any other party than the State or is used for purposes other than conservation, flood control or recreation, it shall revert to the Association.

CONCLUSION: The State is assuming in this project only an annual expenditure of about $100. The benefits to the Town of Weare and to the State of New Hampshire from the construction of this project under State ownership and control so far exceed this amount that the project should be carried through.

LOCATION OF RESERVOIR

The Weare Reservoir is located in the town of Weare, Hillsboro County. It is an artificial body of water formed by a dam across the Piscataquog River about 23 miles above its confluence with the Merrimack River at Manchester and about 2 miles above the village of North Weare. A map of the reservoir and vicinity is included as Figure 1.

BASIC DATA

Drainage Areas

Weare Reservoir	28.84 square miles
Deering Reservoir	4.48 " "
Weare Reservoir uncontrolled	24.36 " "

Weare Reservoir - full pond

Water Surface Elevation	104 (local) 556 (U.S.G.S.)
Reservoir Area	328 acres
Reservoir Capacity	6300± acre feet 274,000,000 cu. ft. 257 ac.ft./sq.mi. (net D.A.) 4.8 inches (net D.A.)
Maximum Drawdown	20 feet

DESCRIPTION OF PRESENT DAM

The present dam is constructed of earth and concrete with a total length of 273 feet. The spillway, located in the old river

bed, is a gravity section of concrete masonry built on ledge with a crest 90 feet long and a maximum height of 28 feet. The permanent crest of this spillway is at elevation 101.0 (local datum). Full reservoir elevation at 104 is maintained by pin type flashboards 3 feet high placed on the concrete crest. At both ends of the spillway are concrete abutment walls between which and the adjacent hillside are earth embankments with a top elevation at 106.0 or 5 feet above the permanent spillway crest. The embankments have concrete core walls extending from the concrete abutment to an adjacent hillside. In the south embankment the core wall was carried to ledge throughout its entire length. In the north embankment, the ledge dropped off and the bottom of the core wall was not carried to ledge but rested on a layer of heavy impervious earth, and was tied into the same material at its end. It was this embankment which was overtopped and carried away in the flood, together with the road which passed the dam at this end.

A sluiceway 25 feet long with permanent crest at elevation 99, two feet below the permanent spillway crest, is located near the south end of the dam. This sluiceway has four sections for six foot stop logs and is spanned by a bridge to permit easy placing and removal of the stop logs.

A 36" discharge conduit of cast iron pipe is encased in concrete at the north end of the spillway. This pipe is controlled

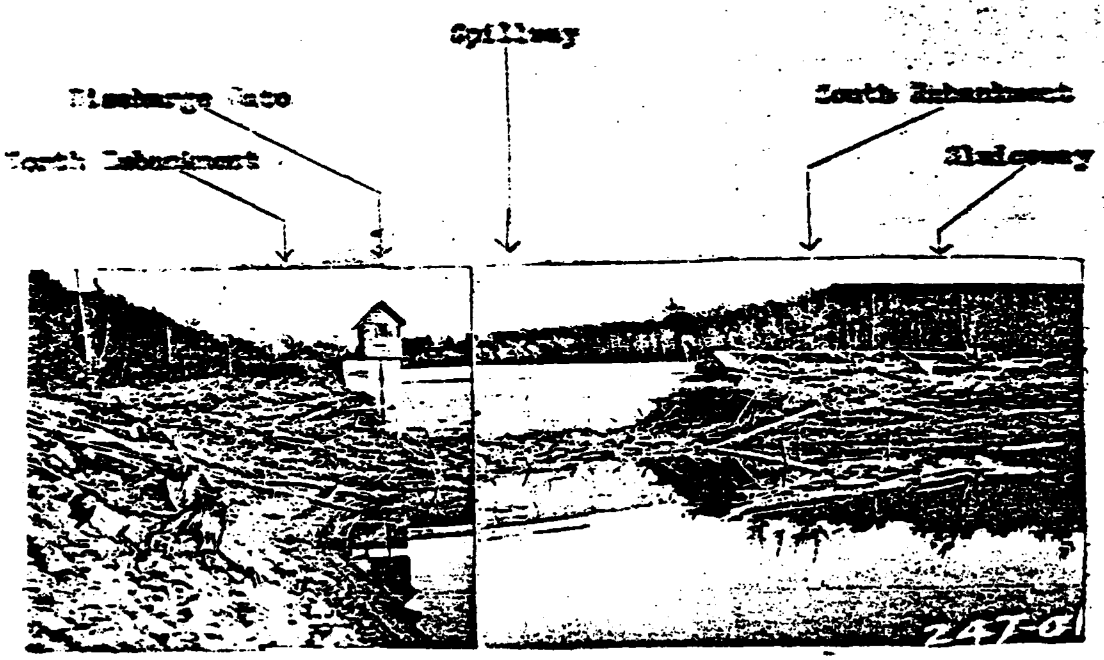


FIGURE 2. DAM BEFORE WASHOUT

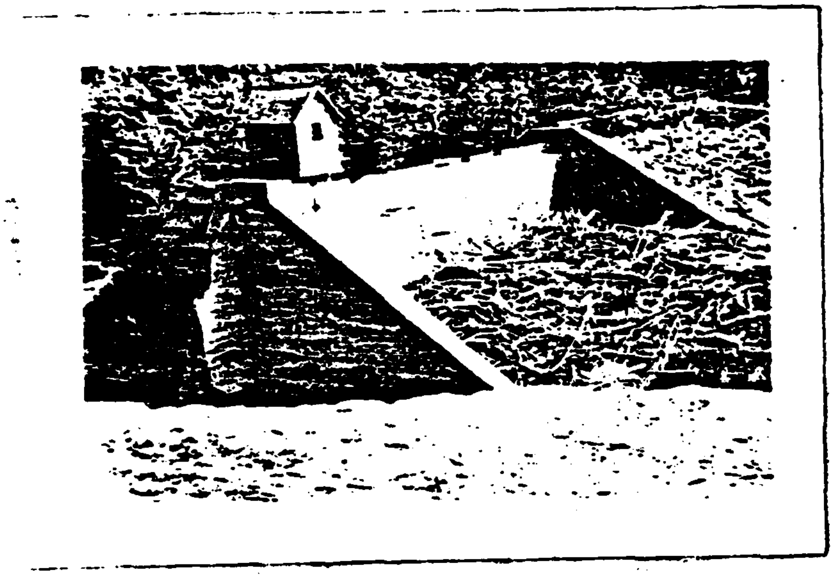
LOOKING DOWNSTREAM

by a 30" gate valve located in a gate well at its upper end. Inspection of this gate is possible by stopping flow into the gate well by a 36" sluice gate.

A view of the dam taken several years ago is included as Figure 2. This shows the dam before the washout during low water condition in the reservoir.

STORM OF SEPTEMBER 1938

The storm of September 1938 which caused the failure of this dam, was of tropical origin and caused unprecedented floods in southeast New Hampshire. The nearest recorded rainfall records were at the Jackman Station of the Public Service Company of New Hampshire about eight miles to the west. These records showed that the main storm began on September 20, when 1.43 inches of rain fell during the 12 hours from 8 A. M. to 8 P. M., and a total rainfall of 2.70 inches for the 24 hours. Rain continued on the 21st and 22nd until a total of 9.94 inches had fallen for the three days. Those three days had been proceeded by a rainy spell of seven days during which period, 2.79 inches of rain fell, making a total for the ten days of 12.73 inches. In Table I are given the daily and cumulative precipitation recorded at Jackman Station for this period.



LEFT ABUTMENT WASHED
OUT IN 1938 FLOOD

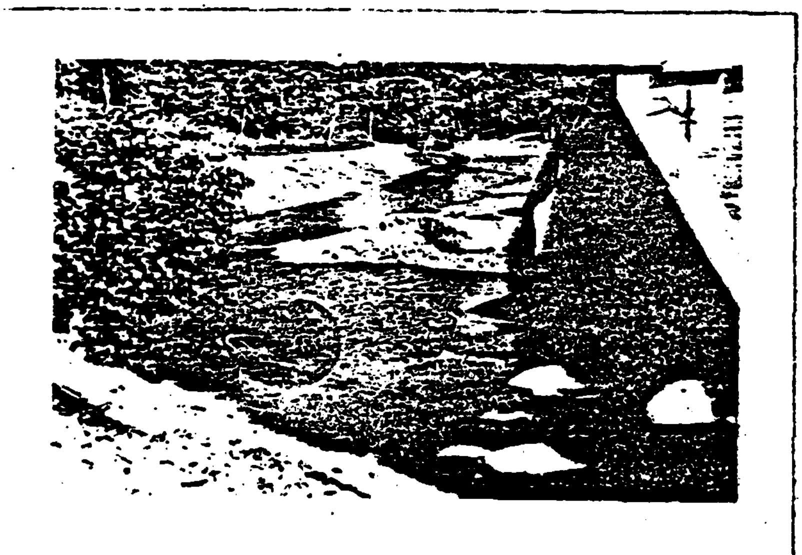


Figure 3. Pictures Showing Condition
of North Embankment after Washout

TABLE 1 - RAINFALL—STORM OF SEPTEMBER 1938

Date	** Rainfall	
	Daily	Cumulative
13	0.86	0.86
14	0.03	0.89
15	0.64	1.53
16	0.62	2.15
17	0	2.15
18	0.20	2.35
19	0.44	2.79
20	* 2.70	5.49
21	4.85	10.34
22	2.39	12.73

* 1.43 inches at 8 P.M.
** Rainfall readings taken about 8 A.M. for previous 24 hours at Jackman Sta.

No definite records are available as to the exact time of the washout. It is believed that Deering Reservoir dam, located about five miles above this reservoir, was overtopped and failed at about 7 A. M. on September 21. This failure released about 4,000 acre feet of water which flowed into Weare Reservoir. It would appear that the Weare Reservoir dam was overtopped about 1:45 P. M. on September 21 and the embankment completely washed out at about 2:30 P. M. of the same day.

PROPOSED RECONSTRUCTION

The proposed reconstruction is shown on a plan No.R56-C5 of the New Hampshire Water Resources Board included in Appendix C. In general, this reconstruction will consist of:

(a) Replacing the earth embankment at the north end of the dam with its top at elevation 108 or 2 feet above the old elevation. The original slopes of $1\frac{1}{2}$ on 1 will be increased to $2\frac{1}{2}$ on 1 and 2 on 1 on the upstream and downstream faces respectively. The embankment will consist of an impervious earth core with gravel shoulders protected by rip rap. Suitable materials are found nearby, tests of which are included as Appendix B.

(b) The heavy retaining walls supporting this fill will be raised 2 feet and strengthened, and the slopes increased to correspond with those of the earth fill.

(c) The old spillway will be strengthened and flow conditions over the spillway improved by a new concrete facing on the downstream slope and on crest. This will correct the present badly eroded condition on the downstream slope of this spillway. The permanent crest will be maintained at the present elevation and provision made for 2 feet of flashboards.

(d) The present outlet works including racks and gates will not be changed but will be put in good condition.

(e) The core wall of the earth fill between the present spillway and the sluiceway will be converted into a new spillway

section by the removal of its upper part and the addition of concrete masonry. The flood washed away practically all the earth embankment originally placed downstream from this core wall, without damaging the wall. This will permit placing this concrete with very little additional excavation. The upper portion of the earth fill upstream from the core wall will be removed to a sufficiently low elevation to give good flow approach conditions. The abutment between this section and the present spillway will remain as it is.

(f) The sluiceway will not be changed except to replace such timber work as has rotted and to put the existing structures in good condition.

(g) A short concrete wall to elevation 128 will be constructed just south of the sluiceway.

(h) The highway north of the dam which was washed out, will be replaced in its original location but raised two feet where it crosses the dam embankment. This road will have a 20 foot roadway with slopes of $1\frac{1}{2}$ on 1 below the dam, riprapped to elevation 80. Above the dam these slopes will be increased to 2 on 1.

ESTIMATE OF COST OF PROJECT

The estimated cost of the complete project is $28,201 distributed as shown in Table 2.

TEST OF CORE MATERIALS

Tests have been made of the available core material in the hillside at the north end of the dam.

A grain size analysis is shown in Figure 4.

The tests show the following characteristics:

Permeability at 20 degrees C with 38% voids — 17×10^{-6} cm/sec.

Specific gravity - - - - - - - - - - - - - 2.77

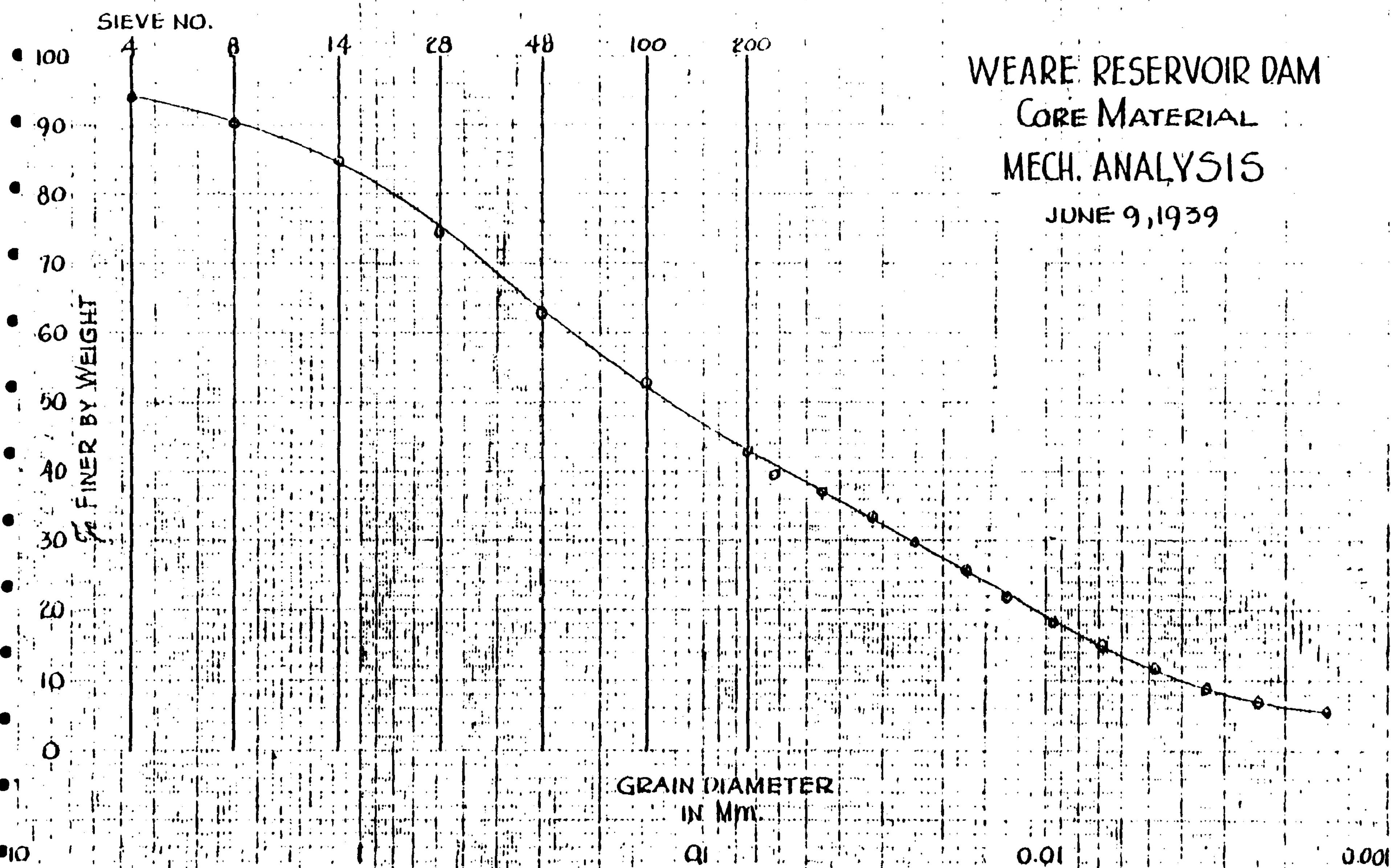

WEARE RESERVOIR DAM
CORE MATERIAL
MECH. ANALYSIS
JUNE 9, 1939
SIEVE NO.
4
8
14
28
48
100
200
% FINER BY WEIGHT
100
90
80
70
60
50
40
30
20
10
0
GRAIN DIAMETER
IN Mm.
10
0.1
0.01
0.001

FIG. 4

WEARE IMPROVEMENT AND RESERVOIR ASSOCIATION.

Contract and Specifications for Building Dam.

This agreement made and concluded this 18th day of January in the year one thousand nine hundred and thirteen, between the Weare Improvement and Reservoir Association by its President, party of the first part; and Fred T. Ley & Company, Inc. by its Vice President of Springfield, in the state of Massachusetts, party of the second part:

Agreement. A. Witnesseth, that the said party of the second part, in consideration of the covenants and agreements herein mutually entered into, and under the penalty express in a bond bearing even date with these presents, and hereunto annexed, does for itself, and successors, covenant, promise and agree to and with the party of the first part, that it the said party of the second part, shall and will in a good and workmanlike manner, at its own proper cost and expense, do and perform all the work and provide all the materials called for, and all tools and labor required for constructing the entire work in accordance with the specifications hereinafter set forth, and the plans furnished and to be furnished, and the directions to be given from time to time as the work progresses, and to the full approval and acceptance of the Association and its engineer; and does further agree that the said Association shall be and is hereby authorized to appoint such engineer and assistants and inspectors under him as it may deem proper, to inspect the materials to be furnished and work to be done under this contract and agreement, and to see that the same correspond with the specifications.

And the said party of the second part hereby further agrees that it will commence work within 100 days of the execution of this contract, and will complete the same in full accordance with

the plans and specifications on or before the first day of September 1913.

B. To prevent disputes and litigation it is further agreed that the same engineer shall decide as to the meaning and intent of these specifications and the quality and quantity of the work required under them, necessary to the proper and full completion of the work; and his decision shall be final and binding upon both parties.

C. Wherever the word "Association" is used in this agreement it shall be understood to refer to the Weare Improvement and Reservoir Association.

Wherever the word "Engineer" is used herein it shall be understood to mean the engineer of the Association or his properly authorized agents, limited to the particular duties entrusted to them.

Wherever the word "Contractor" is used herein it shall be understood to mean the party of the second part to this agreement, or its legal representatives.

D. <u>Specifications.</u>

For Building Dam, etc.

Location — 1. The dam will be built across the North Branch of the Piscataquog River in North Weare, N. H.

Work to be done. — 2. The work to be done consists in building a dam of concrete masonry with large stone embedded, with the necessary wing walls, abutments, core walls, and gate chamber, all of concrete; in making rolled embankments of selected material on each end of dam; in carrying all foundations to a proper footing whether in earth or rock, and in doing all other work contemplate by the plans and specifications.

Quantities. 3. Following are the approximate quantities of work to be done.

850 - cubic yards earth excavation.

250 - cubic yards rock excavation.

2000 - cubic yards concrete masonry.

18 - cubic yards reinforced concrete masonry in gate chamber.

16 - lineal feet of 36" cast iron pipe.

1 - 36" Gate

1 - 36" Gate

3100 - cubic yards earth embankment.

400 - square yards rubble on up-stream slopes of embankment.

Foundations in earth. 4. Foundations in earth are to be carried to such a depth as the engineer may direct and are to be of suitable width to receive the forms of the concrete.

- All trenches and pits remaining after masonry is constructed are to be filled with well puddled and rammed material selected for the purpose.

Foundations in rock. 5. All foundations of walls or ledge are to be carefully cleaned, washed and swept of all dirt and rubbish; all loose portions of ledge are to be removed and all seams filled with mortar, gravel or concrete as may be indicated by the engineer.

If in his judgment the ledge foundations should be of too great a slope, it will be excavated in steps or benches of approximately level section to receive the masonry.

The trenches for cut-off wall under dam and core walls are to be blasted with light charges to avoid shattering the sound ledge on each side of the trench, or opening seams.

Shoring, bailing, etc.

6. All expense of shoring, sheeting, coffer-dams, bracing, pumping and bailing foundations pits in rock or earth shall be included by the Contractor in his unit price for such material.

Management of water.

7. During the entire time of executing the work the Contractor shall at his own expense provide for the proper protection of the same against water, whether from the stream or from surface wash.

All deviating of such water and the providing of suitable channels for carrying it away, together with all necessary flume dams and coffer dams, and all necessary pumping and bailing, shall be done by the Contractor at his own expense.

Excavations to line and grade.

8. Excavations in rock and earth will be made to the lines and grades given by the engineer. The price for excavations shall include the cost of refilling trenches and pits, disposing of the surplus material, pumping and bailing, sheeting and shoring

Surplus Earth.

9. No surplus earth resulting from construction pits and trenches will be paid for as both excavation and fill, unless a haul of more than five hundred (500) feet is required to dispose of it.

Lighting.

10. Measures shall always be taken by the contractor to ensure the safety of the public by such lighting, fencing, or other means as may be necessary.

Measurements of concrete.

11. Measurement of concrete masonry will be allowed of the actual section of the work as built.

Measurements in earth.

Measurements of earth excavation for walls and other structures will be allowed to a width one foot greater on each side than the width required at the depth at that point and with vertical sides.

thoroughly cleaning the same, moistening and adding a layer of mortar before the new concrete is deposited. All concrete shall be mixed fresh for each piece of work for which it is to be used and shall not be used if it has been allowed to stand long enough to take an initial set.

Stone in concrete. 16. In the Dam and abutments and all heavy walls, large stones are to be embedded in the concrete. They shall be placed in a full bed of concrete and shall be completely surrounded by concrete. They shall be laid far enough apart to allow the concrete to be placed around them thoroughly and shall not come within a foot of the outside surfaces of the structure. All stone used must be thoroughly cleaned and all irregular projections, loose portions and feather edges are to be removed by the hammer before the stone is set, but no dressing of such stone will be allowed on the wall or breaking of projections of stone already laid.

Sand. 17. The sand to be used in the concrete must be clean and sharp and is to be approved by the engineer.

Crushed stone or gravel stone. 18. Stone used in concrete is to be clean crushed or gravel stone of a size between one-half inch and two and one-half inches.

36" pipe. 19. The 36" cast iron pipe is to be laid in a full bed of concrete. It is to be laid to line and grade and the joints well made.

36" Gate. 20. A 36" Gate valve will be set in upper end of 36 inch pipe, it is to be carefully plumbed and is to be furnished with a gate rod surmounted by a wheel so as to be operated at the top of the abutment.

Measurement of excavations in rock.

Measurement of rock excavation will be allowed of the actual cross section as removed by the order of the engineer.

Measurement of filling.

Measurement of filling from borrow pits will be allowed of the actual section of such material as deposited in place.

Measurement of pipe.

Measurement of pipe will be allowed of the actual length laid not including gate.

Embankment.

12. The embankment on ends of dam will be built up of material satisfactory to the engineer in horizontal layers not exceeding eight inches in thickness, to be well moistened and rolled and all large stone removed. The down stream slopes are to receive the loam obtained by stripping the site of the dam as a final coating at the expense of the contractor. The up-stream face of embankment is to be rubbled with stone carefull placed at a price per square yard to be included by the contractor in his bid.

Concrete.

13. Concrete in Dam, abutments and core wall is to be compos of 1 : 3 : 5 mixture and in Gate Chamber of 1 : 2 : 4 mixture.

Cement.

14. Portland cement of an acceptable brand is to be used in the work and is to be capable of standing the standard tests of the American Society of Civil Engineers as amended in 1909. It is to be stored in weather-proof sheds and raised above the grou and kept dry. No cement found to be coarse, caked or in any way unsuitable shall be used in this work.

Concrete how laid.

15. All concrete is to be thoroughly mixed and is to be deposited in layers of not more than six inches in thickness and well rammed.?, All surfaces of set concrete or ledge to which fresh concrete is to be added, must be prepared by

Thayer School of Civil Engineering Course ____________

Subject DAM at No WEARE, N.H.

Time, hours ______ Date ______ Computer ______

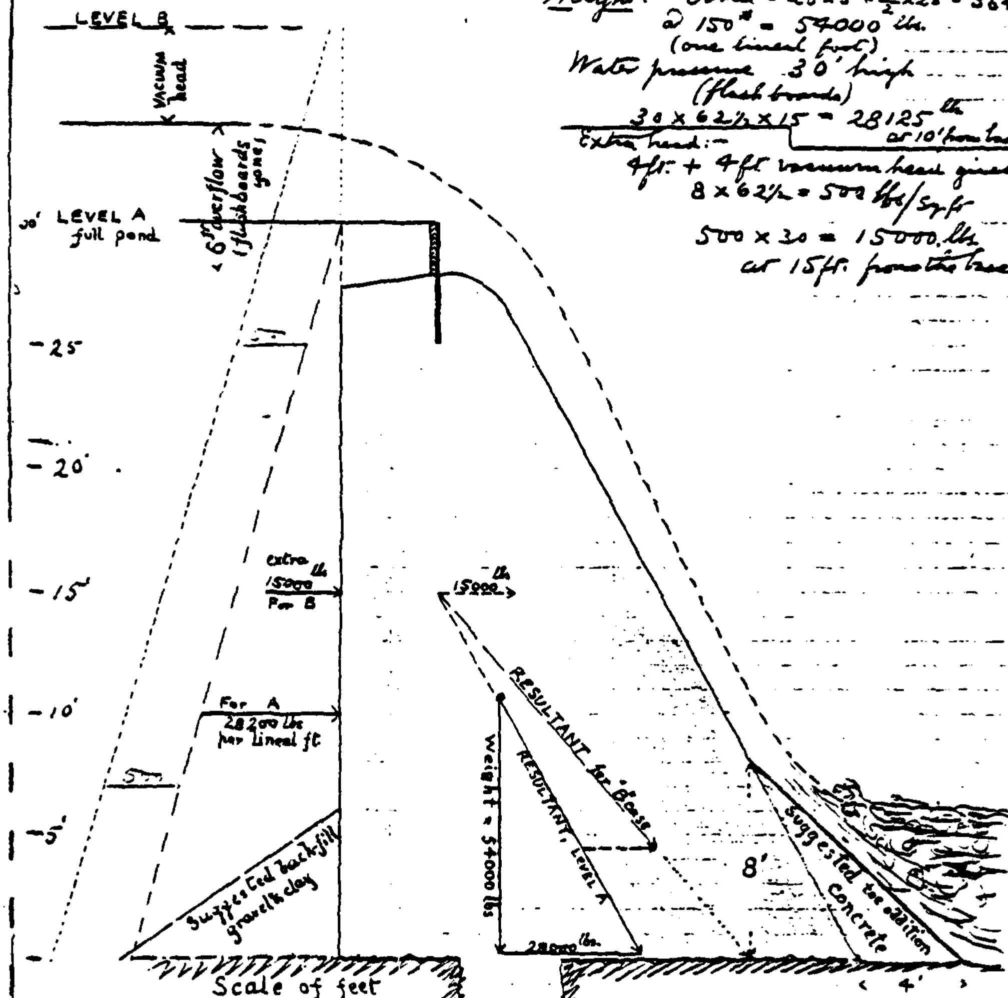
Checked by ______

For other reference see ______

Weight. Area = $28 \times 5 + \frac{16}{2} \times 28 = 364^{\square'}$
@ $150^{\#}$ = 54000 lbs.
(one lineal foot)

Water pressure 30' high
(flash boards)
$30 \times 62\frac{1}{2} \times 15 = 28125$ lbs at 10' from base

Extra head:—
4 ft. + 4 ft vacuum head gives
$8 \times 62\frac{1}{2} = 500$ lbs/sq ft
$500 \times 30 = 15000$ lbs
at 15 ft. from the base



Robert Fletcher
May 1, 1923

Thayer School of Civil Engineering,
CONNECTED WITH DARTMOUTH COLLEGE,
POST GRADUATE COURSE

ROBERT FLETCHER, Ph. D., C. E., DIRECTOR., Prof. of Civil Engineering.
J. V. HAZEN, C. E., Prof. of Civil Eng. on Chandler Foundation.
CHARLES A. HOLDEN, C. E., Prof. of Civil Engineering.
F. E. AUSTIN, B. S., Prof. of Electrotechnics.
SIDNEY L. RUGGLES, C. E., Instructor.

Hanover, N. H. May 1, 1912.

Hon. T. W. D. Worthen,
Public Service Commission
Concord, N. H.

Dear Sir:

According to your request I hereby submit my report and findings in relation to the proposed dam at North Weare, N. H., inspected on the 29th inst., in company with yourself and Mr. John W. Storrs, Civil Engineer.

The plans and specifications on the whole appear to be well-drawn and design well made and adapted to the situation. A few suggestions may be made, however, which need not imply any unfavorable criticism of the skill and competence of the designing engineer; but which involve some larger aspects of the case which those who are more intent upon the immediate constructive details of the problem are apt to overlook.

The first suggestion concerns

THE SPILLWAY.

This has an effective length of 83 feet, nearly, with a possible overflow under 5 feet head to the very surface of the earth embankment. But it would not be safe to allow more than 4 1/2 feet head which would be 6 inches above the top of core wall.

Using Coffin's diagram for wide crested wiers, extending the curve for 10 inch wide crest and assuming the trend of the curve to show 133% of overflow above that from standard Francis weir with 4 1/2+ feet head, I find that this dam might possibly discharge about 2400 second feet with water standing 4/1/2 feet above the crest. - Now the map of this regio in the New Hampshire Atlas (Walling and Hitchcock) indicates about 30 squar miles of drainage area above the dam, - and dividing the above result by 30 we have about 80 second feet discharge per square mile. Reference to data given in Turneaure and Russell's "Public Water Supplies", * shows that this is a possible discharge from such a water shed and may be expected.

The results of computation from measurements of three dams down-stream from this site give only an approximate idea of former floods along this stream. The dams are so various in form, and our knowledge of proper

* John Wiley & Sons, New York, 1908, p. 70.

co-efficients for such forms is so imperfect (as most of the data in books relates only to heads of less than 2.5 feet over the crest), that our figuring upon them has a large element of guesswork.

For the first dam a very definite height of 4 feet (by mark) of flood above the crest, ten years ago, was given by the factory people. Our most probable formula for this shape of dam gives a possible discharge of 2300 second feet * or 76 second feet per square mile. The opening under the bridge below is 30' by an average of 7 feet below the logs, giving 210 square feet. At 8' per second average velocity (easily possible on this steep slope) the discharge would be 1680 second feet, which would probably take off the bridge.

At the second dam the data obtainable was scant and uncertain, not enough even for a good guess. At the third there was definite mark of a flood height of 37" over a dam 84 feet long; but the type of dam was not fully observed. A reasonable assumption of coefficient gives less than 2000 second feet discharge.

So far, therefore, the spillway seems to be adequate; especially when we consider the storage capacity and equalizing effect of 325 acres covered with four feet depth of water. Moreover there are at least two more ponds within the drainage area, - Gregg's and Dudley's - which the writer has not seen. Also another dam was incidentally mentioned, and this should be investigated to learn whether it is in such condition as to be liable to fail and let enough water loose to threaten the safety of the dam being built. If the map consulted is fairly accurate the area of these ponds, with the one to be created, may be 800 acres or more, - say one twenty fifth of the drainage area. Hence every inch of <u>actual run-off</u> would raise these ponds 25 inches deep, if none flowed away; but, allowing one third out-go while the level is rising, - the one inch run-off would raise these levels 16" which would be so much <u>held in check by the ponds</u>, - say 1050 acre feet of water. It would appear therefore that the proposed spillway is ample for 3 inches to 4 inches of actual run-off, <u>if it does not come too fast.</u>

Nevertheless we have to consider the possibility of a cloud-burst, or of a warm February rain when the ground is frozen and covered with several inches of snow. At the Sweetwater dam in California, where a spillway was provided more than sufficient for the greatest floods then known, there came in January 1895 a series of downpours which caused a <u>run-off ten times</u> greater than was believed to be possible, which overtopped the dam two feet deep over its entire length.° At the Hanover reservoir the writer has seen a

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* Treatise before named, page 233, case 31.

° Besides the disch. thru a wide and deep spillway

flow over the spillway of more than 100 second feet per square mile, where the reservoir covers one thirtyfifth of the drainage area of two square miles. At Whippany, N. J. a discharge of 228 second feet per square mile is recorded from an area of 35 square miles, which is only a little more than the area tributary to the proposed dam. The recent excessive rains in Ohio and two other states, where in some districts more than 10 inches fell in three days, is a case in point. Abundant records show that any spot in New England is likely to be the center of excessive rainfall. In the great storm of October 1869, 12 inches of rain fell in three days over a region in Connecticut, and six inches in Hanover, during the same time. In such cases, after the first few hours required to soak the ground, the remainder of the rainfall is nearly all run-off. - Again if a dam above should fail during a time of high water a flood upon a flood would assail the work.

Enough has been cited on this point to justify the First recommendation: that the core wall and abutments be built 18 inches higher. This involves but little extra cost and no change in specifications. This extra height may not be needed once in 25 years; but when the crisis comes the need is desparate.

THE CONCRETE DAM

A suggestion is made here to cover a point usually overlooked in designing such structures. In the accompanying sketch all figures are only approximate, and resultant stresses derived simply by graphical method. Stresses are for one lineal foot only of the dam. The resultant pressure for full pond, as shown, strikes the base near the center. But the additional pressure for the overtopped dam will be uniformly distributed over the entire water face and hence its center of pressure will be at mid height (not at one third height as for pond just full). Assuming a possible flood overflow of six feet depth above the crest, and adding four feet to that for vacuum effect, this additional pressure acting at mid height is (8×62.5=) 500 pounds per square foot uniformly distributed through the entire depth, or 15000 pounds total. As to this vacuum effect I quote from Professor G. S. Williams' discussion of the well known large scale experiments at Cornell Unversity, - Transactions of American Society of Civil Engineers, Vol. XLIV, page 334:-

"One of the most important facts brought out in the past year's investigations in the Cornell Hydraulic Laboratory has been the formation of a vacuum more or less perfect behind the falling sheet when air is not freely admitted. With a weir 6 feet high, the United States Deep Waterways Section, a head of 1.5 ft. has been observed to raise water behind the sheet to a height of 2 ft. above the level of the lower pool, and with a weir 8 ft.

high and a 2 ft. head, the water behind the sheet has stood 5 ft. above the level of the lower pool. The bottom boards of the plank aprons have been torn off frequently, apparently by the suction of the falling sheet at the toe of the dam. .... the pulling off of the granite facing on the downstream side of the Austin Dam, while that at the crest remained practically intact, and other instances of similar phenomena that have been reported, seem to indicate that there may have been a very decided suction there on the occasion of its failure. This teaches that in the design of spillways, the practice of conforming them to the curve of the sheet, in order to obtain a smooth and compact overfall, should be reversed, and every precaution taken to prevent the sheet reaching the foot of the dam in a compact mass."

Now the proposed dam will have an overflow closely confined between the abutment walls with no chance for air to get beneath the stream. A vacuum effect or suction causing unbalanced atmospheric pressure, and adding an uncertain pressure at top of the dam is inevitable. In view of the facts given by Mr. Williams an assumption of four feet for this extra head is certainly conservative. As shown on the drawing the added effect from the overflow (15000 assumed, but 17500 really with flashboards gone) causes the resultant pressure to strike the base so far in the outer third that I recommend 2d a widening of the toe of the dam of at least four feet, extending to a point eight feet up on the face. The additional concrete needed for this would not exceed 70 cubic yards probably.

3d, Another suggestion is that a back fill of sand and clay be made against the heel of the dam as shown in the sketch. Probably the engineer intends to do this anyway, as it is common practise for obvious reasons. The silt which the stream will bring down in time will not be uniformly placed.

4th, The question of temperature and shrinkage stresses in so long a mass of concrete probably has been considered by the engineer. The drawings indicate no provisions for expansion and contraction. Opinions differ as to how far it is desirable in such a dam to use reinforcement to resist these forces. This is not intended as a criticism, and the writer is not prepared to state without more investigation what plan he would adopt. The matter of expansion joints, however, it might be well to consider carefully. The extremes of temperature in our climate usually cause cracks in masonry dams so large; especially when so much is exposed on both sides as in this case when the pond is low. The Wachusett dam of the Metropolitan Water Works, Clinton, Mass., of concrete cyclopean masonry, laid with the utmost care and expense, has shown cracks.

5th, Referring to the specifications, page 3, article 4, I venture

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5th, Referring to the specifications, page 3, article 4, I venture

to suggest that this stipulation is liable to be slighted, unless great care and attention are constantly given to it by the inspector. The contractor is handling the earth by derrick and bucket and his foreman will be tempted to deposit earth too fast. It is required that "All trenches and pits remaining after masonry is constructed are to be filled with well puddled and rammed material selected for the purpose". - The kind of material and its placing should receive the same scrupulous care as the building of the earth embankment. Foremen are apt to think that, having the core wall, the earth behind and in front can be put in almost "any old way". But it must needs be deposited and rammed in layers not exceeding 6 inches in thickness, so that the water cannot anywhere act against the wall under full pressure.

6th, In article 12, page 5, of specifications, I would change eight inches to six inches, so that the spreading of the bucket-loads may be more carefully done. Also require removal of all stones exceeding four inches in diameter.

7th, In article 16, page 6, I would specify that the stones embedded in the mass of concrete shall be separated by at least four inches of concrete and have this very carefully watched so that there may be no voids in the concrete structure.

Trusting that these suggestions will not be viewed as adverse criticism on what is in general an excellent design, I am

Very respectfully,

Robert Fletcher

RF-R

APPENDIX C

INSPECTION PHOTOGRAPHS

Photo No.	Description
1-2	2 photo clockwise sequence looking from road upstream of north end at the upstream face of the dam. Note log debris in water and eroded path and embankment face next to abutment.
3	Looking south across crest from top of north embankment. Note spalling on face of middle wall.
4	Close-up of eroded path on upstream face of north embankment next to concrete abutment. Taken from gate house platform looking down.
5-6	2 photo clockwise sequence looking from downstream channel at downstream face of dam. Note rocks and debris in channel, undermined end of training wall and trees growing in channel.
7	Looking north across crest from top of stoplog spillway. Note log debris on north end of spillway, spalled face of middle wall and slight bow to catwalk.
8	Looking at downstream south bank. Note soil being undermined adjacent to cabin, exposed ledge and trees leaning toward downslope.

1

2

APPENDIX D

HYDROLOGIC COMPUTATIONS

WATERSHED MAP

BY T.T.C. DATE July 78 PROJECT Army Corps Engrs - Dam SHEET NO. 1 OF 6

CHKD. BY ______ DATE ______ Safty Inspection - Weare Reservoir JOB NO. 8-088

Weare Reservoir Dam

Top of Dam El. 108 (662.3 MSL)
Crest of Spillway El. 101 (655.3 MSL)
Height of Dam (Max.) 40 ft.
Length of spillway 157.3'

I. Hydraulic & Hydrological Analysis:

a) Drainage Area: 29 sq. mile includes the 4.5 sq. mile of Drainage area for Dearing Reservoir

b) Storage Capacity: Based on data obtained from N.H. Water Control Commission, the volume of water for 25 ft of drawdown is 6300± Acre-ft. Max. height of spillway is 33 ft. With water surface of 326 Acre at spillway crest, the Max. capacity when water level at top of dam would be about $6300 + 326 \times 7 \cong 8600$ Acre ft.

Size Classification: Intermediate

∴ Hazard Classification: Chase Village located right downstream, and Weare is only 2 miles away, if dam failure, Hazard would be Significant high.

c) Watershed characteristics: Most of the drainage area have steep slope, through there are few small reservoirs upstream, the watershed characteristics should be in the class of Mountainous - Rolling Land.

d) P.M.F: 1450 cfs/sq. mile, estimate peak PMF would be about 42,050 cfs

e) Spillway Design Capacity: Length of spillway 157.3 ft, ogee plus 24' additional spillway with stop logs. Use C=3.6

$$\text{Wave height} = 0.17\sqrt{70 \times 0.15} + 2.5 - \sqrt[4]{0.15}$$

$$= 0.55 + 2.5 - 0.63$$

$$= 2.4 \text{ ft}$$

$$\text{Net Head} = 7 - 2.4 = 4.6 \text{ ft}$$

WHITMAN & HOWARD, INC.
45 WILLIAM STREET, WELLESLEY, MASS.
Engineers and Architects

BY T.T.C. DATE July 78 PROJECT Army Corps Engrs SHEET NO. 2 OF 6
CHKD. BY ______ DATE ______ Dam Inspection - Weare Reservoir JOB NO. 8-088

Spillway Capacity $= 3.6 \times (4.6)^{3/2} (157.3 + 24)$
$= 6439.3$ cfs say 6450 cfs

f) Spillway Capacity at Maximum pool (neglecting wave height)
$= 3.6 \times 181.3 \; (7)^{3/2}$
$= 12088$ say 12100 cfs

Waste Pipe: A 36" φ pipe with center located 23.5' below the spillway crest, neglecting the tail water submerge effect, with water surface at level 2.4 ft. below top of Dam, the pipe has capacity of about:

$$Q = A\sqrt{\frac{2gH}{K}} = 7.1 \times 8.03 \sqrt{\frac{23.5+4.6}{1.45}}$$
$$= 57.01 \times 4.4 = 251 \text{ cfs}$$

When water level at top of dam $Q = 261$ cfs
Total max. capacity $= 12400$ cfs without consider wave effect

" $= 6700$ cfs with wave

g) Water Surface Area: At spillway crest, the water surface area $= 326$ Acres.

h) Surcharge Capacity & Discharge Rating Curves.

Surcharge capacity curve is computed by using water surface area and the height of surcharge.

Discharge rating curve is the capacity of spillway when water not topping the dam, when water surface higher than the top of dam (overtopping) then, treat the dam as broad crest weir. length of dam section $\cong 100$ ft.

When W.S. El. 2' above dam $Q = 3.6 \times 181.3\,(9)^{3/2} + 2.7 \times 2^{3/2} \times 100$
$+ 260 = 17{,}634 + 764 + 260 = 18{,}658$ cfs

When W.S. El. 4' above dam, $Q = 3.6 \times 181.3\,(11)^{3/2} + 2.7\,(4)^{3/2} \times 100$
$+ 270 = 23{,}812 + 2160 + 270 = 26242$ cfs

When W.S. El. 6 ft above dam

$$Q = 3.6 \times 181.3 (13)^{3/2} + 2.7 \times 100 \times 6^{3/2} + 270$$

$$= 30592 + 3968 + 270 = 34830 \text{ cfs}$$

When W.S. El. 8 ft above dam

$$Q = 3.6 \times 181.3 (15)^{3/2} + 2.7 \times 100 \times 8^{3/2} + 270$$

$$= 37917 + 6109 + 270 = 44{,}296 \text{ cfs}$$

when W.S. El. 9' above dam

$$Q = 3.6 \times 181.3 (16)^{3/2} + 2.7 \times 100 \times 9^{3/2} + 270$$

$$= 41{,}772 + 7290 + 270 = 49{,}331 \text{ cfs}$$

The present maximum spillway capacity includes the outlet capacity only amount to about 30% of the peak inflow of PMF.

Surcharge Storage when water level is 9 ft. higher than the dam would be

$$Q = 16 \times 326 = 5216 \text{ Acre-Ft}$$

Say 5220 Acre-Ft.

i) Peak out Flow Determination – Consider Surcharge storage effect. By using discharge capacity curve

$$H_1 = 669.7 - 655.3 = 14.4 \text{ Ft}$$

$$STOR1 = 14.4 \times 12 \times 0.001563 \times 326/29$$

$$= 3.04 \text{ inch}$$

$$QP2 = 42050 \left(1 - \frac{3.04}{19}\right) = 35322 \text{ Cfs}$$

$$H_2 = 668.3 - 655.3 = 13.0$$

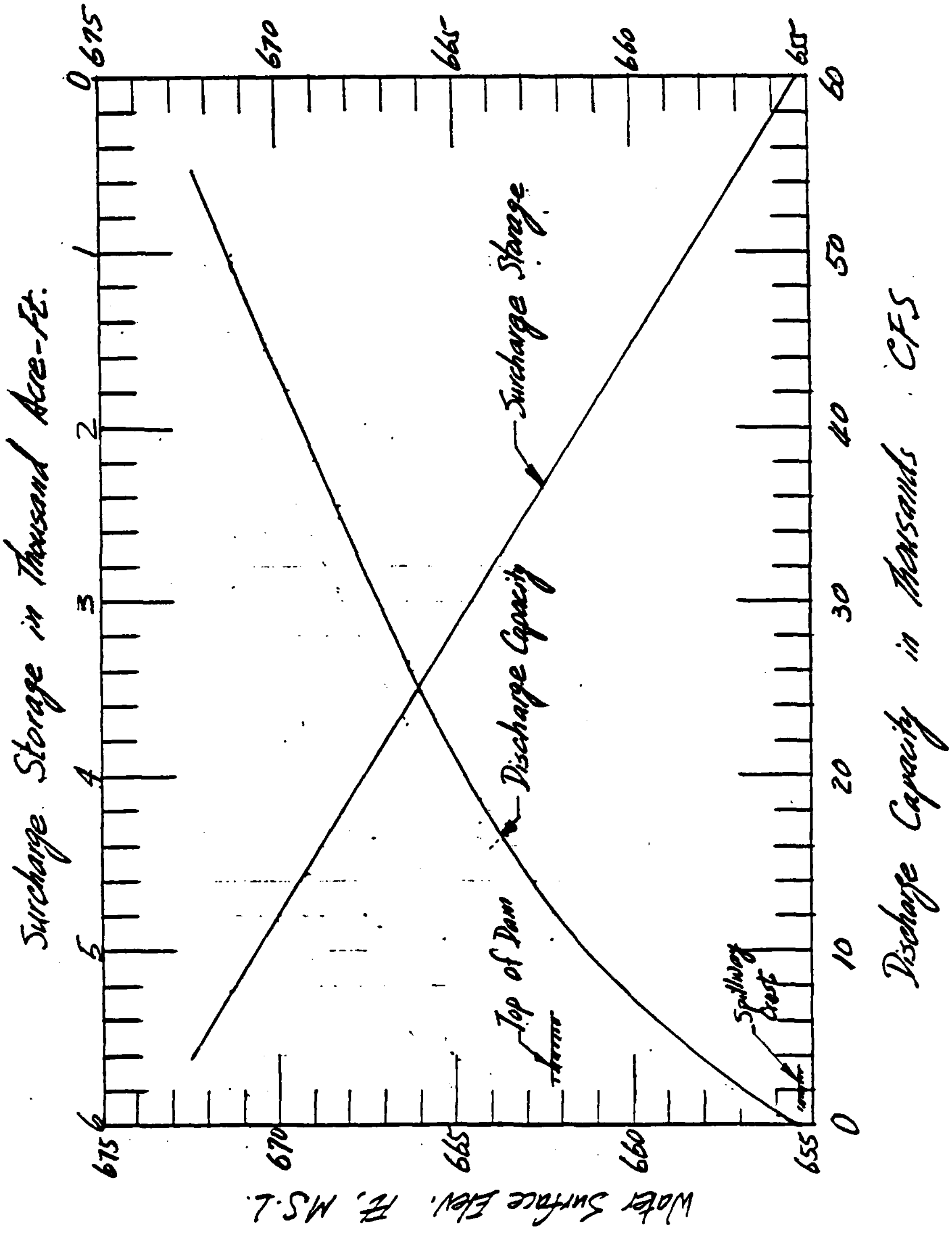
$$STOR2 = 13.0 \times 12 \times 0.001563 \times 326/29 = 2.74$$

$$STOR_{Ave} = \frac{2.74 + 3.04}{2} = 2.89 \text{ inch}$$

BY T.T.C. DATE Aug. 78 PROJECT Army Corps Engrs SHEET NO. 4 OF 6

CHKD. BY ______ DATE ______ Dam Safety Inspection, Weare Reser. JOB NO. 8-088

Discharge Capacity Rating Curve & Surcharge Storage Curve



WHITMAN & HOWARD, INC.
45 WILLIAM STREET, WELLESLEY, MASS.
Engineers and Architects

$QP3 = 42050\left(1 - \frac{2.89}{19}\right) = 35664$ cfs

Say 35700 cfs.

$H = 668.3 - 655.3 = 13'$ above crest of spillway
$= 668.3 - 662.3 = 6'$ above top of dam

j) Improvement:

The right embankment of the dam is a very low concrete section constructed on ledge; therefore overtopping may not be a serious problem.

The left side section of the dam is an earth embankment with impervious core and concrete cut-off. When overtopping the section is the most likely be the one of failure. The length of this section excludes the gate house is about 74 ft.

Assume this 74 ft dam can be converted to spillway, then spillway capacity would be

$Q = 3.6 \times 255.3 \times (7)^{3/2} = 17,022$

Q from outlet conduit = 260

Total 17,282 cfs = 41% of peak PMF

II Visual Inspection & Comments

a) the right embankment is a very low concrete section founded on ledge and in good condition. Concrete of the abutment, the training wall, the spillway do show signs of wear, the pier is in poor shape, Repair is needed.

b) there are lots of wood debris washed down from upstream and deposited on discharge channel and on downstream face of the spillway, it should be clean out.

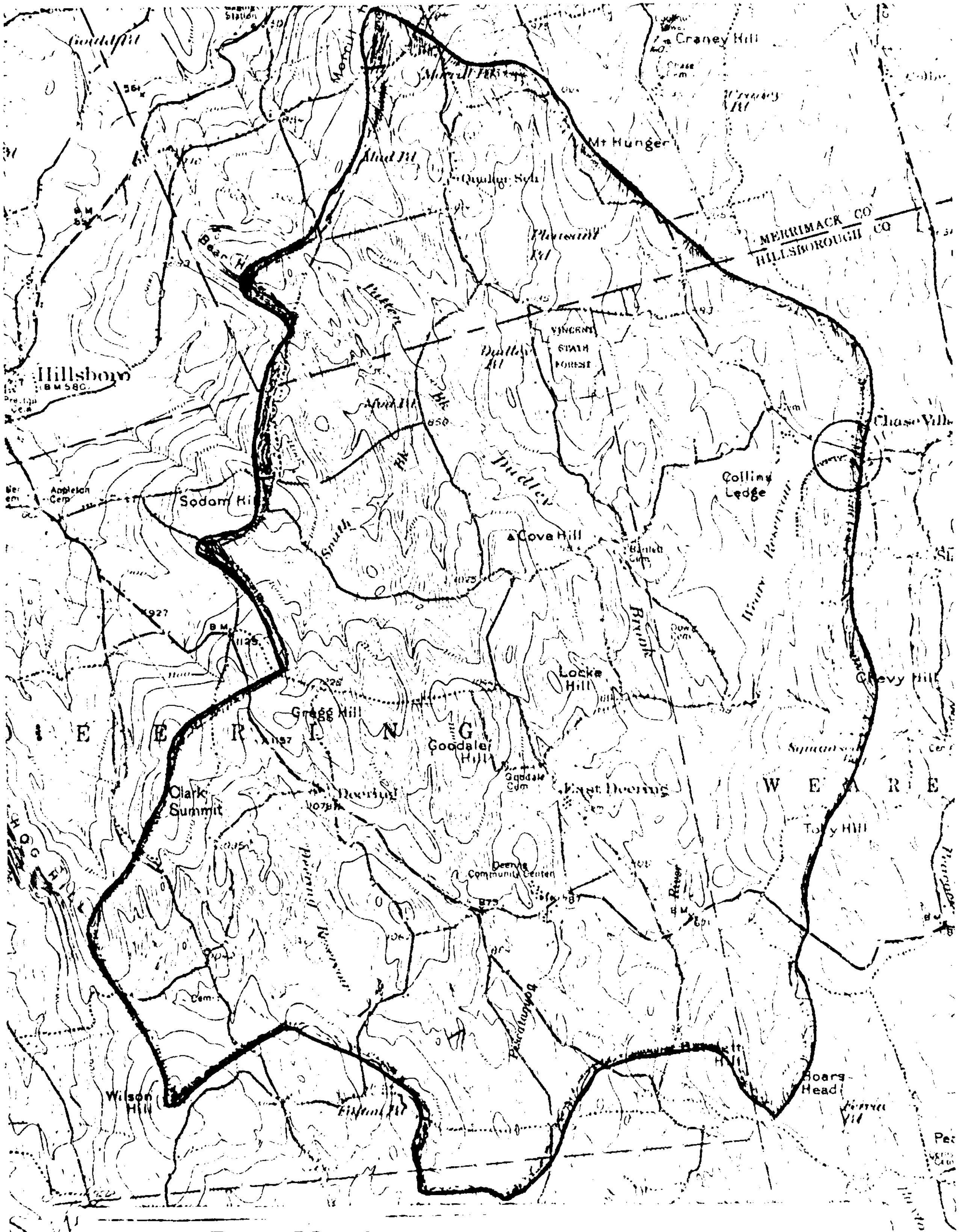
BY T.T.C. DATE Aug 78 PROJECT Army Corps Engineers SHEET NO. 6 OF 6

CHKD. BY______ DATE______ Dam Safety Inspection Weare Reser JOB NO. 8-088

c) Erosion on river bank at right bank near downstream of the dam. This washing back into the bank will threaten the safety of one camp.

d) Due to the relative steep slope of the watershed and the relative large drainage area, the spillway does not have enough capacity, therefore there is potential of overtopping. Weare Reservoir dam been burst during 1938 hurricane.

e) Since the purpose of the dam is for recreation & conservation, the reservoir should be drawdown in late Fall, so to provide storage capacity for early Spring high runoff. In New England, there are two types of possible storm to cause flood, one is the early Spring storm which usually generates high runoff due to the ground is frozen and snowmelt, the other is hurricane during late Spring and summer months. With the reservoir empty, the available storage would reduce the chance of flooding due to Spring storm.



WATERSHED AREA
WEARE RESERVOIR DAM

SCALE 1: 62,500
U.S.G.S. QUARD. SHEET-
(HILLSBORO, N.H.)

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

END

FILMED

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